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1936 ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The forty-ninth annual meeting of the American Association of Economic Entomologists will take place at Atlantic City, N.J., December 28 to 31, in connection with the 1936-37 meetings of the American Association for the Advancement of Science. The Entomological Society of America will hold its meetings during the same period. Chalfonte-Haddon Hall will be headquarters for the Association.

COPIES OF ASSOCIATION ROSTER NOW AVAILABLE

The 1936 official roster of the American Association of Economic Entomologists is being reprinted and will be distributed to those members who attend the annual meeting at Atlantic City, in accordance with past practice. Nonmembers of the Association who want a copy of this list may secure it by applying to the secretary, Ernest N. Cory, College Park, Md., enclosing 50 cents for each copy desired. The list contains 23 pages and includes names of the officers, standing committees, representatives to allied organizations, and the list of members.

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PAPER-READING SESSION, FORTY-EIGHTH ANNUAL MEETING
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GRASSHOPPERS AND AGRICULTURAL DEVELOPMENT IN NORTH DAKOTA[1]

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Historical account.—According to historical accounts of agricultural development in the area now known as North Dakota, the settlers in the northeastern part of the state were the first to experience having their crops devastated by grasshoppers. Referring to an early settlement established in this area in 1851, Shepperd (*11*) states, "Scourges of grasshoppers occurred in the settlement occasionally and were very severe."

Except where otherwise stated, the following references to grasshopper outbreaks during the period 1853 to 1880 are taken from the first, second and third reports of the U. S. Entomological Commission. According to the Commission report, the first notable outbreak was recorded by Governor I. I. Stevens as occurring along the Sheyenne river near Fort Totten in 1853. In his comments on this outbreak he said, "The grass at the best is very poor and the great abundance of grasshoppers has made sad havoc with what had grown here." Lamphere (*6*) points out that in 1854 a heavy infestation of grasshoppers covered the area all the way from the Wild Rice river on the south clear through to St. Joseph (now Walhalla) on the north. This area corresponds to all the eastern border counties of North Dakota, with the exception of Richland county in the southern part of the Red river valley.

In the first report of the Commission, it is stated that Dakota was probably overrun by swarms that invaded Minnesota from the northwest in the year 1856. Professor Otto Lugger (*9*) pointed out that in 1857 locusts destroyed all the crops in the Red river valley so that the infant colony did not have any grain but was obliged to live by hunting and fishing.

Apparently no further trouble was had from grasshoppers until 1863.

[1] Paper 17, Journal series, North Dakota Experiment Station.

According to a report which the Commission credits to G. Emmerling of Walhalla, grasshoppers were troublesome in the northeastern portion of the state for 13 consecutive years, covering the period 1863 to 1875.

Folwell (*2*) records the following note concerning General Sibley's expedition to the Missouri river in 1863: "A four or five days' march over prairies as dry as in November, under a sky clouded by swarms of grasshoppers (locusts), brought the command to the Big Bend of the Sheyenne river. Here it made a halt of a week, from the fourth to the eleventh of July."

Lounsberry (*7*) referring to General Sully's march in August 1864 from the Killdeer mountains through the Bad Lands, by way of Medora (as is) and then northwest to Fort Union, states that: "The country at the Little Missouri was covered with myriads of grasshoppers which had entirely destroyed the grass."

Kingsbury (*5*), in discussing General Sully's campaign of 1864, makes the following observations: "After leaving Big Stone lake, command suffers because of lack of and poor water . . . alkali . . . streams dried up [page 404] . . . grazing poor because of drouth [page 405] . . . The country was rough and barren of vegetation, except large tracts covered with cactus, the only thing left by the locusts, which had quite recently swarmed over the country [page 406]."

In July 1868 an infestation occurred in the vicinity of Fort Totten and was so severe that the army post garden at the fort was destroyed by grasshoppers. Lamphere (*6*) records that in 1870 grasshoppers occurred in the eastern portion of the state and that that year and the year following their ravages were disastrous. He states that in 1874 they came again and stayed three years, eating everything in the Red river valley. Swarming flights of the insects were common. Ludlow (*8*), in reporting on conditions at Fort Lincoln (near Bismarck) in 1874, stated that grasshoppers were on the ground at the rate of about 25 per square foot during late June, and pointed out that they were a serious obstacle to future agricultural development. At Bismarck immense swarms appeared from June 6 until July 15, 1875, causing great damage to all crops except potatoes. The Commission report also refers to grasshopper abundance at Fort Totten and Jamestown in 1875.

Heavy migratory flights.—The following note by Howard (*3*), referring to a contemporary account from Bismarck, North Dakota, is of interest: "On that day (July 7, 1875) a swarm made its appearance before which previous visitations sank into insignificance. The day was very warm, with hazy weather and gentle south winds. At 10 a. m. the locusts were first noticed, on the southwest bank of the Missouri river and in such quantities as to resemble heavy banks of stratus clouds. They passed over this station without intermission from 10 a. m. to 4 p. m. . . . It was almost impossible to estimate the extent and thickness of this swarm, extending from 20 feet above the ground, high into the air, probably 200 feet; and as far as the eye could reach to any point of the compass the air was full of the insects. At 4 p. m. they began to settle on the ground, and by nightfall the ground was covered with them."

According to the Commission report, a large area centering around

Bismarck and extending northward to the Mouse river was seriously infested by grasshoppers during the years 1873 to 1876. The year 1876 is also mentioned as a bad year for other portions of the state, including the towns of Buffalo and Grand Forks, Pembina, and the Red river valley. The whole country extending from the present site of Hebron westward to the Little Missouri river was infested by myriads of grasshoppers in 1876, according to Kellogg (4). In 1877 scattered bands of locusts were observed June 21 at Bismarck, continuing until August 11, and extending as far east as Jamestown.

In 1878 for Bismarck, the Commission reports an infestation as follows: "The swarm was about three miles wide and cleaned up nearly all the gardens, injured corn very much, and trimmed the potato vines. The wheat and oat crop was all harvested before they came . . . Drouth had affected the gardens and the potato crop, but the wheat and oat crop was all that could be desired."

In 1880 the Commission reports state further, "At noon, July 7, while crossing the country lying along the Sheyenne river of Dakota locusts were seen in the air in small numbers, flying to the south-southwest. A few were also seen on the ground. It was supposed that they had hatched in the Red river country and west in the high and dry table-lands."

Regarding conditions in the eighties, Major F. L. Anders, Fargo, tells me that he can distinctly remember the occurrence of grasshoppers in flight in the Fort Ransom vicinity in 1881 and 1882. He states that on numerous occasions, during those two years, his attention was called to the area in the sky, towards the sun, where the grasshoppers in flight appeared like silvery spots in motion. He mentions, however, that the insects did not cause apparent damage either year.

Apparently little trouble was had again from grasshoppers until the nineties. Professor C. B. Waldron, horticulturist at the North Dakota Agricultural College since the establishment of the institution in 1890, relates to me that in 1892 a serious infestation of grasshoppers occurred and continued over a large portion of the state for the three years following. That year, 1892, he was appointed entomologist of the experiment station and college in addition to his duties as horticulturist.

Concerning the outbreak of 1892 to 1895, Waldron points out that in addition to the use of hopperdozers it was the first time poison bran bait was used to destroy grasshoppers in North Dakota and that excellent kills were obtained. In several instances he recalls that the treated areas soon became literally covered with the poisoned insects. He states that grasshoppers caused no further trouble until 1912, when the insects were particularly numerous in the Fargo vicinity.

Outbreaks during the present century.—In the 1912 outbreak, Waldron states that the two-striped grasshopper, *Melanoplus bivittatus* Say, was the predominant species, whereas in the infestation of the nineties more migratory species predominated. Grasshopper incidence was low from then until the serious infestation beginning in 1917. This outbreak, beginning in the southwestern portion of North Dakota in 1917, increased in extent and severity so as to involve the western two-thirds of the state by 1920. The 1921 infestation was confined largely to the north-

central part of North Dakota, while in 1922 and 1923 the outbreaks involved smaller localized areas in the same general region. Grasshopper incidence again dropped until the recent infestation starting in 1931. Very little information is obtainable concerning the species involved in the infestation from 1917 to 1923.

At the outset of the 1917 invasion, direction of control activities was assumed by the extension division of the college, which secured the services of Mr. Stewart Lockwood, extension entomologist. Educational meetings and demonstrations of control work were conducted. Each county participating was required to bear its share of costs. During the more recent grasshopper outbreak in North Dakota practically the same situation with regard to control activities again obtained, except that no extension entomologist was secured until late in 1933, when Mr. Fred D. Butcher was appointed.

The recent infestation had its beginning in 1931 in the northeastern corner of the state, including the eastern half of Pembina county and adjoining portion of Walsh county.

Early in June of 1931, following the first reports of grasshopper hatching in this area, direction of the control work was undertaken by the college extension division, with cooperation extended by the department of entomology. Meetings were held in the area and within a week, following the first reports of grasshopper damage, the farmers were organized and actual control operations were under way. Although success was then realized in controlling the grasshoppers and protecting crops in this area, it was soon apparent that populations were building up in other areas and a more extensive campaign would be required the following year.

Surveys and control activities.—The grasshopper egg survey made in the fall of 1931 showed that a widespread infestation was imminent for 1932 and that an expenditure of approximately $388,191 for poison bait materials would be necessary for control. Timely warnings were given of the impending outbreak, and before the first of May the county officials in all the infested counties were given full instructions in regard to meeting the situation. Not all counties heeded the warning, however, and as a result only about two-thirds of them made preparations for control campaigns. Lack of county funds was given as the main reason for lack of participation. A serious drouth then in progress and extremely low prices of farm products tended towards restricting funds for control.

Not all of the counties participating were adequately financed and as a result control work for 1932 was spotted. Counties which conducted satisfactory poisoning campaigns succeeded in protecting their crops but had the disappointment of seeing their lands reinfested with eggs that fall, largely by the winged migrants coming in from untreated areas. A total of $110,000 was spent by the counties participating in the 1932 campaign—less than one-third the actual amount apparently necessary for adequate control.

A grasshopper-egg survey showed that the infestation for 1933 would practically equal in severity the 1932 situation, except that there was some shifting of grasshopper populations. On the basis of this survey,

it was pointed out that approximately $388,777 would be required for the purchase of poison bait materials to handle the infestation in 1933.

The season of 1933, so far as control activity was concerned, was largely a repetition of the preceding year with the infestation developing closely in line with the forecast made. The counties participating in control campaigns spent approximately $90,000 on poison bait materials. Crops were saved only in the counties where satisfactory campaigns were waged, but migration of grasshoppers from untreated areas occurring late in the season again brought about a widespread menace for the following year.

The results of the 1933 grasshopper egg survey showed that the situation was becoming vastly more serious, as the 1934 campaign would require poisoning operations to be conducted over more than five million acres in North Dakota at an estimated cost of $679,960. By this time the futility of trying to control grasshoppers with meagre county funds for the purchase of poisoned bait was generally realized.

Effectiveness of campaign.—Only the action of Congress in appropriating sufficient funds for adequate control activities over the entire area infested in 1934 prevented disaster and brought about a marked reduction in grasshopper populations that year. In North Dakota it was the first reduction accomplished since the beginning of the infestation in 1931. The effectiveness of the campaign was reflected in the fact that the 1935 infestation was only one-third of that of the preceding year. This success was due to the fact that an adequately financed campaign in 1934 was conducted over the entire grasshopper area and was headed by one directing agency in the state.

The type of campaign which was used was characterized by a comprehensive educational program and extensive organization of all the hopper-infested counties of the state, with each county participating allowed its quota of federal grasshopper bait. The various railroad companies doing business in the state, the Greater North Dakota Association, the Northwest Crop Improvement Association and numerous other business and civic organizations cooperated to the fullest extent towards making the campaign successful. The plan of campaign adopted was in accordance with the procedure developed in Montana (*1*) and used successfully by nearby states in recent years. The help and cooperation extended to the state by Dr. J. R. Parker and his assistants in the Division of Cereal and Forage Crop Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, is particularly worthy of mention. The improvements in technic of conducting surveys, upon which grasshopper distribution and abundance was forecast, and the development of uniformity in the organization and conducting of control campaigns, are due largely to the work of the Bureau. North Dakota will ever remember its great debt to these men for the help which they rendered.

According to accounts in the literature, the grasshopper invasions previous to the present century were usually characterized by heavy migratory flights of the winged adults. This is reasonable to understand because the insects had free scope to develop to maturity and migrate at

will, and there is the possibility that there also existed a difference in the distribution abundance of the species. In the recent outbreak, migratory flights of the adults were only occasionally noticed and seldom attracted more than passing interest because of their light intensity. It is believed that the lesser degree of migration in the recent outbreak is due largely to the poisoning activities, which resulted in killing large numbers of the hoppers before they reached the adult stage. Natural control agencies were of minor significance.

The term migration, as applying to adult grasshoppers, refers to their flight dispersal from previously occupied territory. This tendency to disperse is most evident from overpopulated, drouth-stricken areas where grasshopper control has been inadequate or neglected.

Although migratory flights of the insects were not observed to be intense or numerous during the invasion of the past few years, nevertheless gradual dispersal by flight continued, particularly during the seasons of 1932 and 1933.

Species involved.—The migratory grasshopper, *Melanoplus mexicanus* Sauss., which previous to 1932 was confined largely to its native or normal breeding place in the northwestern counties, increased rapidly in numbers and largely through flight dispersal became troublesome in every county of the state by 1934.

The differential grasshopper, *Melanoplus differentialis* Thomas, which ordinarily occurs only in small numbers north of the southern border of the state, extended its range of activities so as to become the species of major economic importance in 1933 in the southwestern section of North Dakota.

The clear-winged grasshopper, *Camnula pellucida* Scudd., gradually built up from localized areas until by 1934 its range of activity included the northern one-third of the state and the major portion of the Red river valley counties on the east.

The two-striped grasshopper, *Melanoplus bivittatus* Say, confined its activities largely to the Red river valley counties. The satisfactory control campaigns waged in most of these counties, coupled with the nonmigratory tendency of the species, appear to be largely responsible for its limitation to the valley counties.

Packard's grasshopper, *Melanoplus packardii* Scudd., increased in general abundance over the state and by 1933 was frequently encountered along with the other species of economic importance.

The Carolina grasshopper, *Dissosteira carolina* L., also increased in numbers over the state, but was not regarded with concern as it seldom became sufficiently abundant to cause notable injury to crops.

In general, practically all of the many species in the state tended towards increasing in number wherever favorable environmental conditions for their development obtained. One of the particularly significant features of the 1935 survey, following the poisoning campaign of grasshoppers throughout all farmed areas, is the fact that the prairie forms, commonly referred to as wild species, had increased proportionally greater than the economic forms which had been decimated in the poisoning campaign, limited mainly to cultivated areas.

To what extent county poisoning campaigns were offset by grasshopper dispersal from untreated areas is difficult to state. It is a fact, however, that flight dispersal added greatly to the difficulties of the farmers engaged in control work. To illustrate this point, the experience of any one of a number of North Dakota counties might be cited. The experience of Cass county, located in the Red river valley, is quite typical of what occurred.

Flight dispersal an important control factor.—During the summer of 1932, a well-organized and adequately financed poisoning campaign was conducted in Cass county. At the outset more than 85 per cent of the grasshopper population in the county was *Melanoplus bivittatus*, a species which does not have the migratory tendency as highly developed as some of the other economic forms.

The results of the campaign in Cass county that season were highly satisfactory from the standpoints of crop protection and hoppers destroyed, but towards the latter part of summer it was observed that a shift in species populations had occurred. The ratio of species abundance existing earlier had become practically reversed due to the original population being destroyed and supplanted by adult grasshoppers of the more migratory types which flew in from untreated areas after the control activities were concluded for the season. The latter species included largely *Melanoplus mexicanus* and *Camnula pellucida*. The following year, 1933, a poisoning campaign was again conducted in the county, on practically the same scale as the previous year, but this time to control a grasshopper population consisting of more than 85 per cent of the more migratory species—progeny of the migrants which had flown in and laid their eggs during the late summer of the previous year.

Land utilization and grasshopper abundance.—Prior to 1880[2] less than .6 per cent of the land in the state was improved land in farms. According to U.S. Census figures, the percentage of improved land in farms changed as follows: 1890, 10.4 per cent; 1900, 21.5 per cent; 1910, 45.5 per cent; 1920, 54.7 per cent, and 1930, 61.7 per cent.

The grasshopper scourge of the past few years has done much to dispel a belief, held by many, that the breaking up and cultivation of large areas in this region would minimize the grasshopper problem. From the standpoint of grasshopper abundance, it is believed that the 1934 infestation was as serious as any heretofore recorded in the agricultural history of the state. From the economic aspect, the recent situation was of vastly greater importance due to the increased acreage of crops endangered.

At least one of the most migratory and widespread species, *Melanoplus mexicanus* Sauss., lays its eggs as readily in cultivated areas, such as stubble and alfalfa fields, as it does in native sod.

Other species of economic importance, including *Melanoplus bivittatus*, *Camnula pellucida*, and *Melanoplus differentialis*, prefer to lay their eggs in soddy places, such as roadsides, fence rows and pasture lands in the vicinity of cultivated crops. Frequently these soddy areas have been

[2] Figures for 1880 obtained by consolidating data for counties which then occupied the area now known as North Dakota. North Dakota was admitted to statehood in 1889.

found to contain upwards of 20,000 eggs per square foot. It has been observed that the emergence of hoppers from a two to three-foot strip of egg-infested fence row was sufficient to cause complete destruction of fields on either side. These species have been able to reach their greatest abundance in cultivated areas. Our experience has been in agreement with the idea advanced by Parker (*10*) that fields of succulent crops for food and adjacent sod land for egg laying offer more favorable conditions for grasshoppers than existed before the native sod was disturbed by agriculture.—6-29-36.

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HALOWAX (CHLORINATED NAPHTHALENE) AS AN OVICIDE FOR CODLING MOTH AND ORIENTAL FRUIT MOTH[1]

E. P. Breakey and A. C. Miller, *The Ohio State University, Columbus*[2]

Ovicidal properties of *Halowax* having been demonstrated (*3*), studies were undertaken to determine some of the factors that would be involved in the practical application of this material. An attempt has been made to follow a testing procedure which would tend to bridge the gap between the laboratory and the field. Such a procedure must necessarily take into consideration the surface on which the eggs are deposited. The angle of contact made by a liquid with the solid on which it rests is generally conceded to be a valid approach to the wetting ability of the liquid. Stellwaag (*8*) and English (*4*), using this approach, have shown

[1] A Crop Protection Institute project.

[2] The writers wish to acknowledge their indebtedness to the Department of Zoology and Entomology for the use of equipment and accommodations in carrying on these studies. The senior author is now with the Mellon Institute, Pittsburgh.

that the relative ease with which various twigs and leaves are wet with the same liquid varies widely. Evidently then, data gathered from tests made with eggs deposited on apple or pear foliage would tend to be more truly indicative than if they were obtained from tests made with eggs deposited on glass or cellophane.

Preparation.—Larvae of both the codling moth and the fruit moth were collected the previous fall and held in storage. Small apple and pear seedlings, several hundred of each, were planted in 6-inch standard flower pots for convenience in handling. The pots were then sunk in the soil outside where the seedlings would have the benefit of partial shade during the hottest part of the day. The trees were nurserymen's grade 2, one year from seed. Such are preferable to grade 1, because the roots are more branching, a condition which aids in the establishment of the trees in the pots. Experience has shown that the use of pear seedlings has a number of advantages over that of apple seedlings. They are easier to establish, make a more rapid growth, and seem to be less subject to disease. A small insectary shelter was built from plans similar to one illustrated by Peterson (7).

Procedure.—Larvae were removed from storage at intervals during the season. It was planned to have sufficient moths issue at any one time to provide the eggs needed. Fruit moths which had been reared on apples in battery-jar culture cages were used to augment those from storage later in the season.

Trees were selected from the potted stock as needed and brought into the insectary where they were cleaned and put in shape for caging. The fact that the trees had had the benefit of partial shade helped offset the effect of the change in light intensity resulting from bringing them into the insectary. It was often necessary to do some pruning or to remove superfluous or deformed leaves. The soil was scraped away from around each tree until the ground level was lowered to about three-fourths of an inch below the rim of the pot. A thin layer of sand was then spread upon the soil, and a 12-inch cylindrical cage of 16-mesh galvanized-wire screen into the sand. Squares of cellucotton batting, four inches on an edge, were placed on top of each cage. When soaked with water these pads served as drinking founts for the moths. The cages were held in place by stirrups fashioned from rubber bands, one part encircling the pot just below the rim, and the other stretching up over the top of the cage. Bottom water was supplied each tree from the saucer in which the pot stood. The various trees were identified by numbers painted on the rims of the pots in which they were growing, and the seasonal history of each tree was recorded on a separate card.

Fifty or more moths were liberated in each cage through a small hole near the top of the cage. All moths were handled with the aid of an aspirator. It soon became evident that most of the eggs were being deposited on the stem near the soil level, and that the moths remained resting on the sand a good share of the time. In an effort to obtain a greater proportion of the eggs on the foliage, opaque paper bands about 4 inches wide were fastened around the bases of the cages and the moths forced up onto the leaves. In addition the pots were tipped in their saucers at

an angle of 30° with the horizontal and wires with hooks bent at one end were used to draw the foliage closer to the lighted sides of the cages. Such treatment proved very successful and practically all of the eggs were deposited on the leaves of the trees.

When sufficient eggs for a test had been deposited, the moths were removed and the trees taken to the laboratory where they were sprayed. As a result, the age of the eggs varied from one to four days at the time the sprays were applied. All sprays were applied with a Devilbiss atomizer, type GS, operating at a constant pressure of 15 pounds. The trees were then returned to the insectary where they were caged and held for

Table 1.—Effect of the same spray, B & M 62, on the eggs of the codling moth (CM) and the oriental fruit moth (OFM).

Date	Ratio of Halowax to White Oil	Insect	No. Eggs	No. Dead	No. Hatched	Per Cent Dead	Host
July 5	1:2	CM	132	116	16	88	Apple
July 8	1:2	CM	114	105	9	92	Apple
	R*	CM	107	103	4	96	Apple
July 11	1:2	CM	267	235	32	88	Apple
Aug. 14	1:2	CM	60	55	5	92	Pear
	R	CM	118	113	5	96	Pear
June 24	1:2	OFM	52	48	4	92	Pear
	R	OFM	119	103	16	87	Pear
June 29	1:2	OFM	57	54	3	95	Pear
	R	OFM	104	93	11	89	Pear
July 1	1:2	OFM	332	311	21	94	Pear
Sept. 13	1:2	OFM	410	373	37	91	Pear

* R = replicate.

a 10-day incubation period, after which they were returned to the laboratory and the eggs counted with the aid of a jeweler's binocular.

Toward the end of the season when evening temperatures became too low for oviposition it was necessary to move the cages from the insectary shelter to the insectary greenhouse, where very satisfactory depositions of eggs were obtained.

The data listed in the tables were obtained from the use of simple emulsions (designated B & M), prepared by the writers in the insecticide laboratory. All were prepared with the same emulsifying agent, one of the sulfonated fatty alcohols, at 2 per cent on the concentrate, and the formula used called for 80 per cent oil by weight or 80 per cent oil and *Halowax* mixture. All sprays prepared from these emulsions contained 1 per cent of oil, or oil and *Halowax* mixture.

Results.—A total of 15,063 fruit moth eggs was used. Of these, 1856 were in 13 checks taken throughout the season with an average mortality of 3.3 per cent, two going as high as 9 per cent. Of the 7344 codling moth eggs used in these tests, 1500 were in 13 checks taken throughout the season with an average mortality of 5.5 per cent, two going as high as 11 per cent.

Eggs of both insects were killed with the same preparation, there being no apparent difference in the susceptibility of the two, and eggs of

all ages were killed with equal facility. This is clearly indicated by the data in table 1. Most tests were replicated two to four times. Tables 1 and 2 indicate how near these replicates came to giving the same percentages of kill. Since these replicates are representative, individual replicates are not recorded in table 3, but have been combined for economy of space, replicated tests being indicated by the letter R.

Data gathered in an earlier study (*3*) show that it is desirable to use *Halowax* in combination with white oil (petroleum). However, some uncertainty remained as to the most suitable viscosity for the oil. When *Halowax* is added to the oil the resultant combination differs considerably from either of its constituents. Inasmuch as O'Kane, Westgate, Glover & Lowry (*6*) found that the mere addition of a stain might alter to some extent some of the physical characteristics of a spray, additional data pertaining to solution of this problem were sought. It is generally

Table 2.—Effect of white oils of different viscosities on eggs of the codling moth.

Date	Ratio of Halowax to White Oil	No. Eggs	No. Dead	No. Hatched	Per Cent Dead	Host
		B & M 62				
Aug. 14	1:2	60	55	5	92	Pear
	R*	118	113	5	96	Pear
		B & M 67 (Deo Base)				
July 26	1:2	111	0	111	0	Pear
	R	291	4	287	1	Pear

* R = replicate.

understood that the kind of oil and the amount of emulsifying agent produce differences in efficiency. English (*4*) speaking of petroleum oils for use as insecticides on living plants, states: "There may be a wide range of viscosity (from 80 up to 250 or 300) without any appreciable change in volatility," but "When the viscosity drops as low as 60, there is a rise in volatility and a decrease in effectiveness." Others things being equal, an oil having a viscosity of 80 seconds Saybolt is indicated for use with *Halowax*. The data shown in table 2 illustrate two extremes. *Deo Base* is a white oil with a viscosity of 30 seconds Saybolt while the white oil specified for these tests has an unsulfonated residue of 90 per cent plus and a viscosity of 80 seconds Saybolt. Oils having intermediate viscosities gave intermediate results.

The data in table 3 show the effect of varying the ratio of *Halowax* to white oil. Ratios as low as 1:7 were quite effective and the results less erratic than when oil alone was used. Just how much lower the ratio could have been carried was not determined.

Discussion.—Because others (*1*) have had the opportunity of attempting to make use of the insecticidal properties of *Halowax*, and since there may be those who will contemplate doing likewise, the following comments on the use of this material seem to be indicated. These are based on an intensive study of the behavior of the material over a period of several years, and are somewhat supplemental to the conclusions to be drawn from the data presented in this paper.

The choice of emulsifier may mean success or failure. This applies to plant injury as well as to the effectiveness of the insecticide. Some emulsifiers tend to tie up or inhibit the action of the toxin, while others fail to give adequate dispersal. Adequate dispersal is essential to safety to plant life. It is generally accepted that relatively unstable emulsions exhibiting large globules of oil are more effective as insecticides. Such

Table 3.—Effect of decreasing ratio of Halowax to oil on eggs of codling moth and oriental fruit moth.

Date	Ratio of Halowax to White Oil	Insect	No. Eggs	No. Dead	No. Hatched	Per Cent Dead	Host
			B & M 69				
July 30	1:1	CM	186	152	34	82	Pear
Sept. 13	1:1	OFM	449	386	63	86	Pear
			B & M 62				
July 5	1:2	CM	132	116	16	88	Apple
July 8	1:2 R*	CM	221	208	13	94	Apple
July 11	1:2	CM	267	235	32	88	Apple
Aug. 14	1:2 R	CM	178	168	10	94	Pear
June 24	1:2 R	OFM	171	151	20	88	Pear
June 29	1:2 R	OFM	161	147	14	91	Pear
July 1	1:2	OFM	332	311	21	94	Pear
Sept. 13	1:2	OFM	410	373	37	91	Pear
			B & M 63				
July 1	1:3	OFM	576	530	46	92	Pear
Sept. 13	1:3	OFM	294	231	63	79	Pear
Sept. 21	1:3 R	OFM	156	146	10	94	Pear
July 11	1:3 R	CM	210	188	22	90	Apple
July 12	1:3 R	CM	229	216	13	94	Apple
July 19	1:3 R	CM	235	204	31	87	Pear
			B & M 66				
July 24	1:7	OFM	735	578	157	79	Pear
July 25	1:7 R	CM	207	189	18	91	Pear
Sept. 16	1:7	OFM	578	560	18	97	Pear
Sept. 21	1:7 R	OFM	188	158	30	84	Pear
			B & M 65				
July 24	0:1 R	OFM	504	207	297	41	Pear
Sept. 13	0:1	OFM	176	65	111	37	Pear
Sept. 16	0:1	OFM	256	175	81	68	Pear
Sept. 21	0:1 R	OFM	167	98	69	59	Pear

* R = replicated tests.

applies to emulsions prepared from petroleum oils of high purity, but when *Halowax* has been added to the oil another factor enters. English (*4*) states that "Increased effectiveness may or may not be accompanied by an increase in the size of the globules. Increased size of globules is the result of desirable qualities in an emulsion rather than the cause of the effectiveness." In other words, an emulsion in which the oily mixture is dispersed as uniformly fine globules which will be released on coming in contact with insect cuticle or plant surface is desired. For example, it has been shown (*2*) that it takes about .33 per cent *Halowax* in the

spray to be effective as an insecticide when the toxin is dispersed primarily by mechanical action. Such sprays, when properly prepared and applied, are effective against most insects for which a contact insecticide is indicated, and give superior results when used against such forms as the greenhouse red spider, *Tetranychus telarius* L. In marked contrast, we have recently demonstrated that .08 per cent *Halowax* (oil and emulsifying agent being reduced proportionally) is just as effective when the toxin is dispersed by chemical action, and the range of safety to plant life seems to be proportionally increased. Only a few of the many emulsifying agents tested have had the desired properties.

The proportions at which the emulsifier is used will have a direct bearing on the results obtained. Increasing the percentage of the emulsifier reduces the effectiveness of the insecticide. For example, one of the sulfonated phenyl-phenol compounds has been tested and discarded. When this material was used at .5 per cent on the concentrate and the emulsion diluted to contain .33 per cent *Halowax*, the spray killed about 90 per cent of the eggs. However, when used at .5 per cent on the concentrate and the emulsion diluted to contain the same percentages of *Halowax* and oil, the spray killed only about 30 per cent of the eggs.

Similar results should not be expected from the use of the emulsions on all insects. O'Kane, Westgate & Glover (*5*) found that each contact agent (emulsifier) exhibits a varying angle of contact on different insects, due possibly, to the varying nature of their integument. From the practical point of view it is desirable to have an insecticide kill as great a variety of insects as possible. The effectiveness of contact insecticides is due to a considerable extent to the success with which the contact agent functions. Fortunately, the emulsifying agents now under test seem to have these qualities.

Summary.—An attempt has been made to determine some of the factors involved in the application of *Halowax* as an ovicide for the codling moth and the oriental fruit moth.

Larvae of both insects were collected the previous fall and held in cold storage. These were removed from storage at intervals during the season so that sufficient moths would issue at any one time to provide the eggs needed. Additional fruit moths which had been reared on apples in battery jar culture cages were used to supplement those from storage later in the season.

The moths were induced to oviposit on the foliage of small apple and pear seedlings which had been grown in 6-inch flower pots for convenience in handling.

The age of the eggs varied from one to four days at the time the sprays were applied. All sprays were applied with a Devilbiss atomizer, type GS, operating at a constant pressure of 15 pounds. At the end of a ten day incubation period, the eggs were counted with the aid of a jeweler's binocular.

Halowax was applied as a simple emulsion prepared by the writers in the insecticide laboratory. The emulsifying agent, one of the sulfonated fatty alcohols, was used at 2 per cent on the concentrate, and the formula called for 80 per cent oil by weight, or 80 per cent oil and *Halowax* mix-

ture. All sprays contained 1 per cent oil, or 1 per cent oil and *Halowax* mixture.

A total of 15,063 fruit moth eggs was used. Of these, 1856 were in 13 checks taken throughout the season with an average mortality of 3.3 per cent, two going as high as 9 per cent. Of the 7344 codling moth eggs used, 1500 were in 13 checks taken throughout the season with an average mortality of 5.5 per cent, two going as high as 11 per cent.

Eggs of both insects were killed with the same preparation, there being no apparent difference in the susceptibility of the two, and eggs of all ages were killed with equal facility.

It had been demonstrated that it is desirable to use *Halowax* in combination with white oil (petroleum). However, some uncertainty remained as to the most suitable viscosity for the oil. Other things being equal, *Halowax* gives the best results when diluted with an oil having a viscosity of 80 seconds Saybolt.

The effect of varying the ratio of *Halowax* to oil was studied. Ratios as low as 1:7 were quite effective and the results less erratic than when oil alone was used. Just how much lower the ratios could have been carried was not determined.

Earlier work had demonstrated that the choice of contact agent (emulsifier) had much to do with the degree of success obtained from the use of *Halowax* as an ovicide. It was also found that the proportions at which the emulsifier is used will have a direct bearing on the results obtained. Increasing the percentage of emulsifier reduces the effectiveness of the insecticide.—8-26-36.

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Federal plant quarantine 7, which prohibited the entry into the United States of white pines, currant and gooseberry plants from Europe, Asia, Canada and Newfoundland, and federal plant quarantine 20, which prohibited the entry of certain pines from Europe, have been lifted by the Secretary of Agriculture, effective September 1. Control will be continued under foreign plant quarantine 37, which provides that plants can be imported only under permit and such safeguards as are necessary to protect against the entry of various pests.

COMPARATIVE METHODS OF REMOVING LEAD LOADS RESULTING FROM A HEAVY FIRST-BROOD OIL–LEAD SCHEDULE

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In 1934 the oil–lead combination used in both first and second-brood codling moth sprays resulted in lead loads ranging from .23 to as high as .50 grain per pound. Whenever the lead loads on the 1934 samples were above .23, it was difficult to clean the fruit below tolerance without injury. This was especially true of varieties, such as Grimes, Jonathan and Delicious. Winesap and Kinnard were resistant to injury even when cleaned of lead loads running as high as .43.

In 1935 it was the original plan to apply a very heavy first-brood schedule using oil–lead and to use lead arsenate and 1:3:100 Bordeaux in second-brood sprays. Half of the 80-acre Purdue orchard at Bedford received six first-brood covers, of which all but the first contained 4 pounds of lead arsenate and one-half per cent summer oil plus one-half pound of soap. The other half of the orchard received the same schedule but without soap. After the sixth cover had been applied on July 1, 2 and 3, it was evident that serious foliage injury might result from additional sprays containing lead arsenate, and no further applications were made from that time to harvest. All cover sprays were heavily applied from the inside and outside of the trees using stationary spray equipment.

Table 1.—Lead and arsenic loads resulting from a calyx and six cover sprays. Last cover July 1–3, 1935.

Spray	Grimes		Winesap	
	Lead per Pound in Grains	Arsenic per Pound in Grains	Lead per Pound in Grains	Arsenic per Pound in Grains
Six covers, five with lead arsenate, oil and weak Bordeaux or lime	.120	.049	.098	
Six covers, five with lead arsenate, oil, soap and weak Bordeaux or lime	.205	.056	.158	.054

The harvest lead loads on Grimes and Winesap resulting from this schedule are shown in table 1.

Addition of soap to the spray combination increased the harvest load of both lead and arsenic. By applying first-brood cover sprays at approximately seven-day intervals it is possible to build up a rather high harvest load of lead and arsenic that is very resistant to cleaning except with heated solutions. There was a two and one-half-month period between the date of last spray application and harvest on Grimes and a three-month period on Winesap. Grimes apples were 14 to the pound on July first.

Method of collecting samples.—The method of sampling was changed

from that used in 1934 and previous years. All of the apples were collected from the ground and from the outside area of the trees by the same person. All fruits were taken from trees within one spray pattern, sprayed all season by the same gunman. This large sample was run over a Cutler sizer which weighs the fruit into quarter-inch sizes. Only fruit falling into the $2\frac{1}{2}$-inch bin was used for comparative treatments. This effort to start with a more nearly uniform lead load per apple resulted in much fewer "off" analyses than in the past years of this work.

Types of washers used.—Nearly all of the new washing equipment installed in Indiana packing sheds in 1934 and 1935 has been of the underbrush-flood type. For this reason the greater part of the removal work in 1935 was done by this class of washer, although duplicate samples of some treatments were again run through a Model X flotation type and the same tandem hook-up used in 1934.

Comparative efficiency of washers.—The underbrush-flood washer, as in 1934, gave the best percentage of removal. On Grimes (carrying a lead load of .205) a 20-second exposure in cold acid gave a removal of 85 per cent, and up to as high as 94 per cent with $1\frac{1}{2}$ per cent acid and three-quarters per cent *Vatsol* for 20 seconds at 100° F was recorded.

The tandem hook-up with acid in the brush unit for 30 seconds at 105° F, followed by cold acid for 1 minute in the flotation section, gave a lead removal of 90 per cent on Grimes (before load .205) and 83 per cent removal on Winesap (before load .098). This same tandem hook-up was used in 1934 with hot sodium silicate in the brush unit (not an underbrush-flood) and the percentage of lead removal was not so good as that obtained by a single treatment in the underbrush-flood washer at 30 seconds exposure.

A single flotation treatment in 1935, using 1 per cent acid plus one-eighth per cent *Vatsol* for one minute at 75° F gave a removal of 78 per cent on Grimes and 76 per cent on Winesap. Flotation washing has always resulted in lower percentage removals in this work, but this type of machine can be built to give a large capacity per hour and there is less danger of mechanical injury to the fruit. The washing solution in this type of washer is easily and cheaply heated even with electric heating units. Repairs and replacements are fewer than in the underbrush-flood or flood type washers. Where lead loads do not run higher than four or five times the tolerance these machines are ideal if used in conjunction with a dry-cleaning unit to polish the fruit.

Time of exposure.—Lengthening the time of exposure can always be depended upon to increase removal. The practical drawback to this recommendation is that most packing sheds are equipped with washers about one size too small and this requires operating at top speed to handle the crop. The normal exposure for underbrush-flood washers is either 20 or 30 seconds. Our work in 1934 and 1935 indicates that with this type of washer an 85 per cent removal at 20 seconds can rarely be increased to more than 87 or 88 per cent by slowing down the machine to 30 seconds. This small increase in removal is costly from the standpoint of reduced hourly capacity of the washer.

Increasing temperature.—Increasing the temperature 20° above nor-

mal in the underbrush-flood washer will result in practically all cases in as good or better removal as lengthening the exposure from 20 to 30 seconds. Increasing the temperature from 67 to 100° F stepped up removal from approximately 86 to 92 per cent on Grimes and from 75 to 85 per cent on Winesap. Provision to heat the washing solution is a very necessary precaution in every packing shed. In 1935 early freezes caused premature ripening in much of the central west, and picking was often thousands of bushels ahead of washing and packing operations. This delay meant increased difficulty in washing which frequently could

Table 2.—Representative lead analyses of apple samples exposed to various treatments in three types of washing equipment, 1935.

Composition of Washing Material	Temperature of Bath (F)	Seconds Exposure	Grimes		Winesap	
			Grains of Lead per Pound after Treatment	Per Cent Lead Removed	Grains of Lead per Pound after Treatment	Per Cent Lead Removed
Model E Underbrush-flood Washer						
No treatment			.205		.098	
1½% HCl	67	20	.028	86	.025	75
1½% HCl	100	20	.015	92	.015	85
1½% HCl + ¾% *Vatsol*	100	20	.011	94	.011	89
1½% HCl + ⅛% *Vatsol*	100	20	.019	90	.015	85
1½% HCl + ⅛% *Vatsol*	67	20	.034	83	.024	76
2¼% HCl + ¾% *Vatsol*	69	20	.027	87	.016	84
2¼% HCl + ¾% *Vatsol*	69	30			.014	86
Model X Flotation Washer						
1% HCl + ⅛% *Vatsol*	80	60	.045	78	.024	76
Tandem Washed, Using Underbrush Unit Followed by Model X Flotation Washer						
1½% HCl+⅛% *Vatsol* in underbrush	105	30	.018	91	.017	83
1½% HCl+⅛% *Vatsol* in Model X flotation	82	60				

be met in a practical way only by the use of heated washing solutions. Toward the end of the packing season, shed temperatures average 10 to 15 degrees lower and natural waxes increase on the surface of the fruit, either of which may call for the use of heating equipment.

Value of a wetting agent.—In the 1934 work delays in washing often made it impossible to compare treatments. Considerable work was done on samples which had been stored from one week to three months and under these conditions *Vatsol* with cold as well as hot acid increased removal.

In 1935, treatments for comparison were run within 36 hours after picking. Following this procedure, the use of *Vatsol* at one-eighth and three-quarters per cent with 1½ per cent cold acid failed to increase definitely the lead removal in underbrush-flood washing. However, when three-

quarters per cent *Vatsol* was used with cold 2¼ per cent acid, a worthwhile increase in removal resulted on Winesap but not in the case of Grimes. This higher removal on Winesap would seem to be the result of increasing the acid strength, but in previous work raising the strength of acid above 1½ per cent had given very little increased removal.

One-eighth per cent *Vatsol* gave no increased removal when used with hot acid in the underbrush-flood washer. When the strength of *Vatsol* was increased from one-eighth to three-quarters per cent and again used with hot 1½ per cent acid, there was a better percentage of removal, which was not improved by raising the acid strength to 2¼ per cent.

Method of analysis.—A 50-apple sample was used for all treatments. Out of this sample were selected three 12-apple samples which carried the most visible residue. Lead determination was by the dithizone colorimetric method, and the three separate samples were averaged to obtain the final figure. As usual, the results of a few of the analyses in 1935 did not conform with the statements made in this paper. However, much of the work reported is a duplication of 1934 work, using the same washing equipment. A few representative analyses are given in table 2 to illustrate the results discussed above.

Treatment of 2¼ per cent acid plus three-quarters per cent *Vatsol* has been used only one season. This treatment will be repeated in 1936. The underbrush unit used in the tandem treatment consisted of a series of brushes running partly submerged in acid and without the flood action of the Model E underbrush-flood. No injury was found on any stored sample from these treatments.—8-26-36.

ATTRACTION OF CUCUMBER BEETLES TO THE BUFFALO GOURD

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It is well known that adult cucumber beetles, *Diabrotica* spp., are attracted to the injured vines and fruits of melon and squash, but apparently this chemotropic response has not been taken into consideration as a possible lead towards the development of control measures. The fact that the buffalo or wild gourd, *Cucurbita foetidissima*, was strikingly attractive to *Diabrotica soror* Lec. was observed in 1920 by the junior author, who noticed the beetles, a few minutes after an automobile had run over the vine, collecting in large numbers on the crushed stems and leaves. The additional fact that the sliced or ground root of this plant was highly attractive to several species of cucumber beetles has been recorded in unpublished notes made at San Antonio, Tex., during the period from May 1929 to October 1931, by E. V. Walter and A. A. Mathewson, of the Bureau of Entomology and Plant Quarantine. These observations were corroborated by the authors in a series of experiments conducted near Alhambra in southern California during 1934, when it was determined that the beetles of three species of *Diabrotica* occurring

commonly in the locality were attracted markedly, not only to the ground root of the buffalo gourd, but also to the ground leaves, stems and fruit of this plant. The species of beetles involved in the tests at Alhambra were the western striped cucumber beetle, *Diabrotica trivittata* Mann., the western spotted cucumber beetle, *D. soror* Lec., and the banded cucumber beetle, *D. balteata* Lec.

The buffalo gourd, appearance and distribution.—According to Smiley (*3*), *Cucurbita foetidissima* is a rough, prostrate vine characterized by an unpleasant odor and a large carrot-shaped root. It has stout stems 6 to 16 feet long, which take root at their joints and bear branched tendrils, large alternate leaves and yellow flowers. The leaves, which are triangular, 4 to 12 inches long and half as broad, are borne on stout leaf stalks. The leaf blades are rough above the hairy below. The ovary is solitary, inferior, becoming a dry, round, smooth gourd 2 to 4 inches in diameter. Gray (*1*) gives the distribution of this gourd as Missouri to southern California and Texas. He refers to it as the "Missouri gourd," or the "fetid wild pumpkin." According to Jepson (*2*), the Spanish Californians, who called this gourd the "Calabazilla" or "chili coyote," used its roots as a cleanser and its leaves medicinally. Other local representatives of the same family, *Echinocystis fabacea* and *E. macrocarpa*, are also attacked by the cucumber beetles.

Experiments at El Monte.—The leaves, stems, roots and fruit of the buffalo gourd were ground separately in a food chopper. Then a pint of each plant part was put on each of eight paper plates. The 32 plates, composed of four groups of eight, were then placed in a squash field at El Monte, Calif., known to be infested with *Diabrotica soror* and *D. trivittata*, but in which *D. balteata* had not yet been observed. The plates of baits were placed on alternate ridges between the rows of squash, covering an area 80 feet square. Each plant part occurred twice in each row with the position in the row determined by random placement. The baits were set out at 3:30 p.m., July 12, 1934, and the experiment was terminated at 4 p.m., July 13. The beetles were collected by hand at intervals during this period. The bait was so attractive that many beetles alighted on the plates before they were in position. The material was moist with plant juices at the beginning of the test, but the stems and leaves dried out rapidly. Although the fruit and roots contained less moisture than the leaves and stems at the beginning of the test, they retained their moisture for a longer period.

The numbers of beetles collected at the various baits are shown in table 1.

The adults of *Diabrotica soror* were attracted in approximately equal numbers to the fruit and leaves (29.8 and 28 per cent, respectively), slightly less (25 per cent) to the roots, and considerably less (17 per cent) to the stems. However, 47 per cent of *D. trivittata* were attracted to the stems, while only 22, 18 and 13 per cent were attracted to the fruit, leaves and roots, respectively. *D. balteata*, which was not in evidence during the first afternoon of the tests, appeared the next morning. The adults of this species were not attracted to the leaves, but 65 per cent of them were attracted to the roots, 20 per cent to the fruit, and 15 per cent

to the stems. The stems and leaves, which were more attractive at the beginning of the test than the fruit or roots, were dried out by the middle of the second day. The fruit, which retained its moisture longer than the other plant parts, showed a gradual increase in the number of beetles coming to it during the period of the experiment. The roots increased in attractiveness until the loss in moisture content became critical, and then decreased. Apparently the attractiveness of each of the plant parts varies directly with its available moisture content.

Experiments at Santa Ana.—A second series of experiments was arranged near Santa Ana, Calif., where *D. soror* and *D. balteata* were the predominating species, with *D. trivittata* assuming a minor role. The

Table 1.—Numbers of cucumber beetles, *Diabrotica* spp., collected in bait pans containing ground parts of the buffalo gourd plant, 1934.

	July 12			July 13				Total	Mean per Bait
	3:30 p.m.	4:30 p.m.	5:30 p.m.	10 a.m.	2 p.m.	3 p.m.	4 p.m.		
				On Leaves					
D. trivittata	30	48	51	73	32	22	18	274	34.2
D. soror	20	42	33	45	45	21	15	221	27.5
D. balteata	0	0	0	0	0	0	0	0	0.
Total	*50*	*90*	*84*	*118*	*77*	*43*	*33*	*495*	*61.7*
				On Stems					
D. trivittata	92	119	75	149	146	68	50	699	87.4
D. soror	11	11	16	31	29	23	14	135	16.9
D. balteata	0	0	0	0	1	2	0	3	.4
Total	*103*	*130*	*91*	*180*	*176*	*93*	*64*	*837*	*104.7*
				On Roots					
D. trivittata	19	32	48	57	16	9	10	191	24.
D. soror	12	17	8	83	53	19	5	197	24.6
D. balteata	0	0	0	5	4	4	0	13	1.6
Total	*31*	*49*	*56*	*145*	*73*	*32*	*15*	*401*	*50.2*
				On Fruit					
D. trivittata	7	19	13	110	120	39	28	336	42.
D. soror	1	4	4	83	70	45	27	234	29.2
D. balteata	0	0	0	2	1	0	1	4	.5
Total	*8*	*23*	*17*	*195*	*191*	*84*	*56*	*574*	*71.7*
				Total					
D. trivittata	148	218	187	389	314	138	106	1500	46.9
D. soror	44	74	61	242	197	108	61	787	24.6
D. balteata	0	0	0	7	6	6	1	20	2.5
Total	*192*	*292*	*248*	*638*	*517*	*252*	*168*	*2307*	*72.4*

leaves, stems and fruit were ground together and exposed from 11 a.m. to 1:30 p.m., July 20, 1934. Eight baits attracted a total of 221 *D. soror*, 250 *D. balteata*, and 14 *D. trivittata* in two and a half hours.

Experiments with traps.—The use of traps to confine the beetles attracted to these baits was considered next. Several types of traps were tested, but none of them was successful. Beetles were attracted to the vicinity of the trap containing the ground leaves and stems, but they would alight only on the plants. The use of metal electrocuting traps in in conjunction with the buffalo gourd bait was a complete failure, as is illustrated by the collection of only three beetles in an electrocuting trap in two hours, followed by the attraction of 30 beetles to the same bait in 15 minutes after the trap had been removed.

Water extracts of the buffalo gourd.—Further tests were made to determine the response of cucumber beetles to a water extract of the stems and leaves. Six plants containing the water extract were placed in a squash field at El Monte in such a manner that each was shaded by

squash leaves. The beetles were attracted to the baits, and in their efforts to reach the source of the odor many of them fell into the bait containers. The collections of beetles from these pans are shown in table 2.

Table 2.—Numbers of cucumber beetles, *Diabrotica* spp., collected in bait pans containing extract of buffalo gourd leaves and stems, 1934.

	Trap 1	Trap 2	Trap 3	Trap 4	Trap 5	Trap 6	Total
			July 31—Aug. 2				
D. soror	89	88	41	12	15	73	318
D. trivittata	47	71	7	11	36	107	279
D. balteata	1	2	2	0	1	2	8
			Aug. 2—6				
D. soror	346	289	0*	120	60	17	832
D. trivittata	29	53	0*	19	7	3	111
D. balteata	14	11	0*	5	1	2	33
			Total				
D. soror	435	377	41	132	75	90	1150
D. trivittata	76	124	7	30	43	110	390
D. balteata	15	13	2	5	2	4	41
							1581

* These pans were dry.

Experiments with poisoned baits.—The first series of experiments at El Monte included one set of four baits that were poisoned with Paris green and a similar set poisoned with sodium fluosilicate. Apparently the addition of these poisons to the bait repelled the beetles that had been attracted to the immediate vicinity of the baits by the odor of the ground parts of the buffalo gourd plant.

Conclusion.—From the results of the preliminary observations reported in this paper, it is apparent that both the ground parts and the extracts of the buffalo gourd are very attractive to several species of cucumber beetles, thus suggesting the possibility of utilizing the attractive substance present in this plant as bait. Such a bait, if its indicated possibilities could be fully developed, might prove particularly effective in attracting and trapping or poisoning the overwintering cucumber beetles during their initial migration into the cultivated fields in the spring.—7-20-36.

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CHINCH BUG FLIGHTS

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During the spring of 1934, severe injury by chinch bugs was observed in Kansas along the margins of wheat fields adjoining grassy roadsides. This observation raised the question as to whether the chinch bugs

crawled or flew into such wheat fields from their hibernation quarters and what factors governed their movements.

Flint (*2*) says, "In the spring the bugs fly out of winter cover on the days when the temperature is above 70° and the sun is shining. Before flight there may be considerable activity in winter quarters, the bugs crawling about and mating. Our observations in Illinois show no general flight until the temperature is above 70° and during sunny days." Few definite observations, however, have been published on the effect of temperature on the flight of chinch bugs.

To study the flights of this insect in the vicinity of Manhattan, Kans., two pairs of flight screens were erected on March 9, 1935, and daily examinations of these were made throughout the spring, summer and

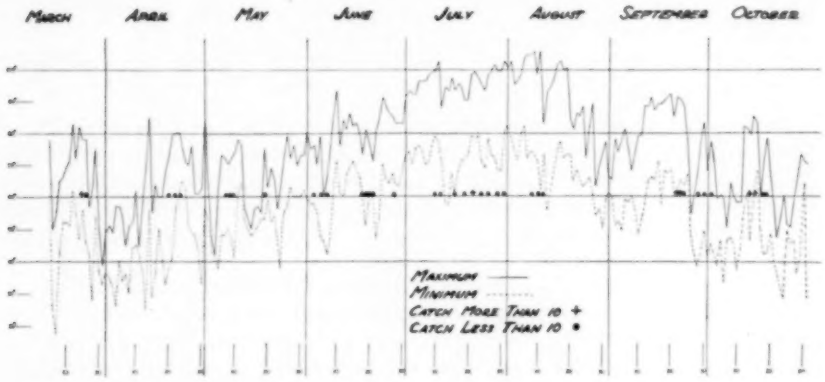

Fig. 1.—Relation between air temperatures (F) and flights of chinch bugs. The symbols + and ● indicate dates on which flights occurred.

fall. The screens were similar in construction to those used by Fenton & Dunnam (*1*) in their studies of the cotton boll weevil. Each unit consisted of 14-mesh window screening stretched over a frame 3 by 5 feet made of 1 by 4-inch sheathing. They were erected on posts in pairs placed at right angles to each other and about 3 feet above the ground. One pair was located between a field of sorghum stubble, known to be harboring chinch bugs, and some experimental wheat plots, and the other in sod known to be well infested. Tanglefoot thinned with turpentine was applied to the screens and found to be very effective. It caught and held not only chinch bugs but many other insects as well. Amyl acetate was found to be satisfactory for cleaning the captured insects taken from the screens. It dissolved the tanglefoot within an hour without apparent injury to the insects.

Air temperatures throughout the season were recorded by a thermograph. Records of sod temperatures during March, April and May were made by means of a thermocouple bulb buried in a clump of *Andropogon scoparius*, a typical sod in which chinch bugs were hibernating. Sod-temperature readings were taken daily at 8:30 a.m. and at 2:30 p.m.

Table 1 records the daily catch of chinch bugs by the two pairs of flight screens throughout the spring, summer and fall of 1935. It may be noted that there were four general movements or flights of the chinch bug during the season. Indications of the relation of sod and air temperatures to these flights can be obtained by reference to fig. 1, which contains

Table 1.—Daily catch of chinch bug adults on two pairs of flight screens at Manhattan, Kans., 1935.

Date*	No. Females Captured	No. Males Captured	Total No. Captured	Date	No. Females Captured	No. Males Captured	Total No. Captured
Mar. 25, 26	9	5	14	July 10–19	6	3	9
Apr. 20–23	11	6	17	July 22–31	37	45	82
May 8–19	5	2	7	Aug. 8–12	8	4	12
June 3–7	1	5	6	Sept. 22–Oct. 2	28	29	57
June 18–27	4	6	10	Oct. 14–19	56	46	102

* Only days on which chinch bugs were caught are included in the table.

the daily maximum and minimum air temperatures throughout the season, and to fig. 2, which records the maximum temperatures in sod from March 15 to May 15 at Manhattan, Kans.

Prior to March 23, two days before the first capture on the flight screens, the maximum daily sod temperatures were in the fifties or lower. The first flight occurred after sod temperatures had attained a maximum of 60° F or higher for a few days, and the maximum air temperatures

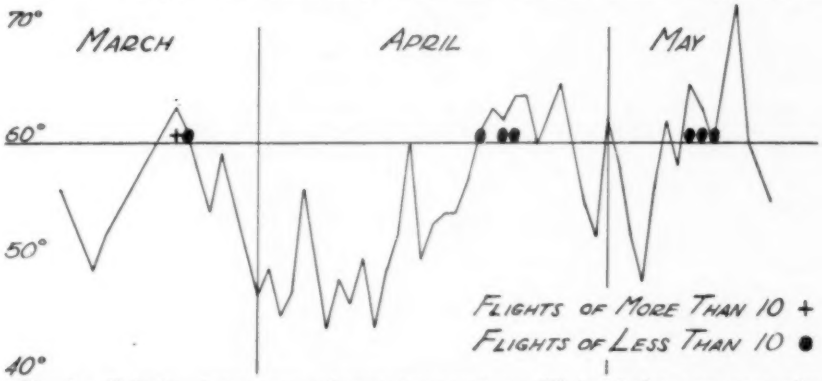

Fig. 2.—Relation between maximum temperatures (F) in *Andropogon scopurias* sod and flights of chinch bugs. The symbols + and ● indicate dates on which flights occurred.

ranged from 69 to 83° for four successive days. Periods between flights were usually periods of low temperatures, and several days of continuous warm weather were required to induce further flight. Such a period of low temperatures occurred between the first flight on March 25 and 26 and another flight from April 20 to 23. Maximum air temperatures were distinctly below 70° F during this interval except on April 14, which was six days before the second flight started. Maximum air temperatures

during this second flight ranged between 73 and 80° and maximum sod temperatures from 60 to 64°. Flights of redistribution occurred during May and June, when there were marked fluctuations in temperature. Abnormally low temperatures in May had a noticeable effect upon the movements of chinch bugs. Records of the Weather Bureau, U. S. Department of Agriculture, for Manhattan, Kans., show a mean temperature for the month of 60.2°, which is 4.3° lower than normal for May. As a result, oviposition was delayed and heavy rains prevented the summer brood from reaching the winged stage until late in July. A third or summer flight of the new brood to other fields took place during July and August. On July 22 the heaviest screen catch of the season was made, indicating the peak of the summer flight. This flight started about July 16 and continued throughout the month. Small flights in August

Table 2.—Summary of chinch bug flights by months, 1935.

	No. Females Captured	No. Males Captured	Total No. Captured	No. Flight Days
March	9	5	14	2
April	11	6	17	3
May	5	2	7	4
June	5	11	16	8
July	43	48	91	9
August	8	4	12	3
September	27	29	56	5
October	57	46	103	5
Total	165	151	316	39

reflected the urge to fly, as the maturing nymphs developed wings and became adults. The fourth or fall movement toward hibernation occurred at definite periods in September and October. These fall flights followed depressions in the minimum temperature curves. The flight peak for September took place on the twenty-second and twenty-third and for October on the fourteenth and sixteenth. During the spring, the flights from hibernation occurred when the temperature of sod, where the bugs had wintered, reached 60° F, but in the fall the flights to hibernation quarters were apparently induced by corresponding drops in the temperature.

Tables 1 and 2 show that in 1935 the chinch bugs were caught in flight on a total of 39 days. Field examinations indicate that five of these days were periods of movement away from winter quarters; 24, periods of redistribution in the breeding fields; and 10, movement toward hibernation.

However, the periods of redistribution are concerned with two separate broods, the overwintering brood and their progeny. The chinch bugs that fly out of hibernation have a redistribution flight whereas the newly winged forms have a distribution flight to new fields and later fly to hibernation quarters. Although these may be considered as three seasonal movements each brood has two flying periods, making a total of four general flights, one in the spring, two in the summer and one in the autumn.

To obtain information on the distribution over wheat fields of chinch bugs migrating from hibernation quarters, samples were taken from fields in numerous localities in Kansas. Each sample consisted of 10 linear feet of wheat in the drill row, soil for 2 inches on each side being taken with the wheat plants. This material was placed in tight cloth bags and taken to the laboratory for sifting and examination.

Samples were taken at points within 5 and 10 feet and approximately 100 feet from the margins of 24 fields. The results obtained from an examination of these samples are given in table 3.

Table 3.—Distribution of migrating chinch bugs in Kansas wheat fields, 1935.

Date Sample Taken	Location of Field	No. Chinch Bugs in Sample	
		From Margin of Field	100 Feet from Margin
April 22—May 17	Riley county	10	4
May 20	Wabaunsee county	159	61
April 16—May 23	Lyon county	126	59
May 29	Marshall county	2	1
May 29	Nemaha county	2	2*
May 29	Brown county	3	4
May 29	Atchison county	1	0
May 29	Jackson county	18	3†
Total		321	134

* One field of oats.

† One field of spring wheat.

The data of table 3 show a total of 321 chinch bugs in samples taken from the margins of grain fields, in contrast to 134 in samples taken 100 feet from the margins. This indicates the tendency of migrating chinch bugs to stop at the margins of the fields, or as soon as they reach an attractive food supply.

Summary.—Data obtained from flight screens in connection with sod and air temperatures, made by thermocouple bulb and thermograph respectively, show that when chinch bugs migrate from winter quarters their flights are governed largely by changes in temperature. Flights from places of hibernation occur in spring when the temperature of the sod in which the bugs are hibernating reaches 60° F. Redistribution flights occur late in the spring and during the summer when air temperatures fall below 60° F and then rise distinctly above that temperature. Flights to places of hibernation occur in the fall after drops in temperature corresponding to the temperature increases observed in the spring. In spring, migrating chinch bugs stop at the margins of grain fields, or as soon as they have reached an attractive food supply.—7-16-36.

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The Alabama Department of Agriculture and Industries has placed a quarantine relating to the potato tuber moth which forbids entry of seed potatoes from Florida unless shipped between May 20 and June 20, held in cold storage till June 30, and inspected before being shipped. The quarantine is dated May 6.

BLOOD ALBUMIN SPREADER USED WITH OIL SPRAYS

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Blood albumin is marketed in three forms: flake, granulated and powdered. In making these products the freshly drawn blood is defibrinated and dried at a temperature below its coagulating point. Where the drying is done in pans, a flake product is obtained; and where spray-drying is employed, a finely divided powdered product is obtained. The powdered form when mixed with a wetting agent dissolves readily in water, due to its finely divided state, and is therefore particularly well adapted for use as a spreader for sprays.

The relative merits of powdered blood albumin spreader in comparison with other substances as spreading, wetting and emulsifying agents in governing the oil-depositing and covering qualities of oil sprays, have been presented in former publications by Smith (*3*, *4*) and Bordon (*1*). Its special merits may be briefly stated as follows: It is relatively unaffected by the salts that may be present in water used for spraying. It is highly efficient as indicated by the fact that 4 or 6 ounces to 100 gallons of spray is sufficient to produce a wetting and a normal oil deposit on foliage and fruit. It is advantageous economically, the net cost of the raw ingredients being about one-third cent an ounce. During the past several years it has been used rather extensively, particularly in California and the citrus area of Texas where tank-mixture spray has been generally employed.

The specifications for the spreader call for 1 part of powdered blood albumin and 3 parts of fuller's earth or a similar form of earth, intimately mixed; the albumin to be not less than 96 per cent water-soluble, to have a moisture content not greater than 6 per cent, and 90 per cent or more to pass through a 100-mesh screen; the spreader to be packed in glassine-lined paper bags as a precaution against deterioration. The data presented hereinafter indicate that the standard for moisture content should be a maximum of 8 or 9 per cent rather than 6 per cent.

The investigations reported in this paper were made with the object of securing data on the range in quality of the albumin and of the spreader as produced by different manufacturers, and the effect of different types of earths on the keeping and performance qualities of the spreader. A further object was to develop a method for determining the solubility of the spreader.

Moisture and solubility tests for blood albumin spreader.—The method for determining the moisture content and the solubility of blood albumin spreader that has been employed by the authors during the past few years and that is employed at present by the trade concerned is given below.[1]

To determine the moisture content of the spreader, weight out a 5-

[1] Acknowledgment is made of the cooperation of the laboratories of Armour and Company in the development of these methods of analyses.

gm. sample and dry in an oven for 16 hours at a temperature of 105 to 110° C. Cool to room temperature in a desiccator, reweigh and calculate the loss in weight as per cent moisture.

To determine the soluble solids, weigh a 20-gm. sample into a 600 cc. beaker containing 100 cc. of boiled and cooled distilled water, and thoroughly break up all lumps. Transfer to a 500 cc. volumetric flask, carefully wash down the sides of the neck of the flask so that all the sample is in the water, and add rinsings of the beaker to the flask. Use freshly boiled and cooled distilled water in all the procedure. Fill the flask to 450 cc. and keep it at a temperature of 38° C for one hour, shaking gently occasionally. Fill to the 500 cc. mark and empty the contents into the 600 cc. beaker previously used. Let stand for two hours to permit most of the earth to settle to the bottom of the beaker. Filter the clarified liquid through a No. 2 Swedish filter paper, discarding the first 50 cc. of the filtrate. Let the filtrate stand overnight to allow any earth to settle to the bottom that might have passed through the filter. Place a 50 cc. aliquot in a weighed evaporating dish and evaporate to dryness. Place the dish in an oven and dry for 16 hours at a temperature of 105 to 110° C. Cool to room temperature in a desiccator, weigh and calculate the residue as per cent soluble solids in the basis of a moisture-free sample, in accordance with the formula $\frac{\text{Weight of residue} \times 10 \times 100}{\text{Weight of sample} - \text{weight of moisture}} = \text{Per cent}$ soluble solids.

As indicated elsewhere in this paper, the method is not entirely accurate because it does not take into account the fact that some of the albumin is adsorbed by the earth.

Tests on the range in quality of blood albumin.—During 1934 a leading manufactuer of powdered blood albumin submitted samples of each lot of albumin that was shipped from Pacific coast warehouses to the several manufacturers of the spreader. Samples were also submitted by some of these manufacturers. The analyses of 14 samples received showed that the soluble solids ranged from 95.78 to 99.91 per cent. The moisture content ranged from 6.45 to 9.52 per cent, with an average of 8.03 per cent.

A 15-pound shipment of albumin was received from the manufacturer in January 1934. Analysis made at that time showed the soluble solids to be 97.95 per cent and the moisture 8.82 per cent. Part of the shipment was used in making spreader coincident with our investigations and the reminder was held in the wood drum in which it was shipped, until the following year, January 1935, when it was again analyzed. This analysis showed the soluble solids to be 92.7 per cent and the moisture 8.95 per cent. During the period of 12 months' storage, the drum had a piece of wrapping paper tied over the top and was set under a bench in the laboratory. Under this condition of storage the decrease in solubility during the year was approximately 5 per cent.

Tests with different types of earths.—The original studies showed that to cause the powdered blood albumin to wet readily when placed in the spray tank, it should be diluted with some form of earth which would serve mechanically to carry the albumin into the water. The studies indicated that the performance qualities of the spreader were not

particularly influenced by the character of the earth. However, a special investigation of this factor seemed desirable. In January 1934, five manufacturers of the spreader supplied samples of their products and also samples of the earths used in preparing the products. At the same time a 15-pound quantity of powdered blood albumin was obtained from a manufacturer of that product. Samples of the spreader were prepared in the laboratory, using the different earths received from the manufacturers and the 15-pound sample of albumin.

Analyses were made of all the samples before they were taken to the orchard for oil-deposit tests. A duplicate set of the samples was kept in the laboratory in order that analyses could be made a year later to determine what effect the different earths might have on the keeping quality of the spreader.

In the oil-deposit tests the spray was applied in the usual commercial manner by a licensed spray operator. Grade 2 spray oil (*4*) was used in

Table 1.—Analyses of blood albumin spreader and determinations of oil deposit resulting from the use of manufacturers' samples and samples prepared in the laboratory.

Manufacturer	Samples Supplied by Manufacturer			Samples Prepared in Laboratory		
	Moisture	Soluble Solids	Oil Deposit*	Moisture	Soluble Solids	Oil Deposit*
	per cent	*per cent*	*cc.*	*per cent*	*per cent*	*cc.*
1	8.25	15.1	.76	4.96	19.72	.71
2	8.39	10.15	1.03	8.96	22.62	.74
3	9.84	19.97	.67	10.59	23.04	.71
4	6.99	19.09	.77	6.44	22.18	.69
5	2.92	24.92	.69	2.83	24.7	.66

* Oil deposited on 1000 square inches of orange leaf area.

tank-mixture spray in the proportion of 1½ gallons to 100 gallons of spray and the spreader was used in the proportion of 4 ounches to 100 gallons of spray. Oil-deposit determinations were made by a modification of the ether-extraction method of Rohrbaugh (*2*). Results of the analyses and the oil-deposit determinations are shown in table 1.

The oil deposit that was produced by the samples supplied by manufacturers 1, 3, 4 and 5 was regarded normal, within the range of error. The oil deposit that was produced by the sample supplied by manufacturer 2 was considerably higher than normal. In this connection it was observed that the wetting quality of the spray in which this sample was used was much below normal. These facts were correlated with the low solubility of a particular brand of blood albumin that the manufacturer had used in making the spreader. The oil deposit of all the samples that were prepared in the laboratory was regarded normal within the range of error.

Absorption of albumin by earths.—The differences in the percentage of soluble solids shown by the samples of spreader prepared in the laboratory indicate that the earths have different capacities of adsorbing the albumin in the process of the solubility test. If no adsorption had occurred, the sample prepared with the earth of manufacturer 1 should have shown 22.85 per cent soluble solids, since the albumin and the

earth showed 97.95 and .72 per cent soluble solids, respectively. However, since the oil deposit produced by the spreader is normal, it is evident that the factor of adsorption is not important where the spreader is used in the normal concentration and the usual manner of orchard spraying. In the solubility test the concentration of the spreader is more than 3000 times that used in orchard spraying, and the earth and

Table 2.—Moisture and soluble solids of earths obtained from different manufacturers.

Manufacturer	Moisture	Soluble Solids
	per cent	*per cent*
1	2.9	.72
2	8.08	.54
3	11.39	1.91
4	6.24	.37
5	.38	.05

albumin remain together in the liquid medium for a period of three hours.

The per cent moisture and the per cent soluble solids of the earths used in preparing the samples are given in table 2.

Storage tests of the spreader.—Packages of a certain brand of the spreader were collected and kept in the laboratory for periods ranging from approximately four months to 20 months, after which analyses were made. The results of the analyses are shown in table 3. No analyses of the samples were made at the beginning of the storage tests to determine any differences in solubility that existed. However, control tests made with samples of the earth and the albumin supplied by the manufacturer indicated that approximately 19.7 per cent soluble solids is normal for the freshly made spreader, there being an adsorption of about 5 per cent of the albumin in the process of the solubility test. It

Table 3.—Moisture and soluble solids of samples of the spreader analyzed after periods of storage.

Sample	Date Packed	Date Analyzed	Moisture	Soluble Solids
			per cent	*per cent*
1	June 1, 1933	Jan. 23, 1935	4.73	17.31
2	June 1, 1933	Jan. 23, 1935	4.61	16.33
3	June 1, 1933	Jan. 23, 1935	4.57	17.19
4	May 21, 1934	Jan. 23, 1935	4.75	19.57
5	May 21, 1934	Jan. 23, 1935	4.9	18.94
6	Sept. 1, 1934	Jan. 23, 1935	4.06	19.1

appears, therefore, that during the storage of 20 months of samples 1, 2 and 3 there occurred a decrease in solubility of 1.75 per cent, and that during the eight months' storage of samples 4 and 5 there occurred a decrease in solubility of .45 per cent.

The duplicate samples of spreader that were prepared in connection with the tests referred to in table 1 were kept in the laboratory for one year and then again analyzed. The results of the analyses, shown in table 4, indicate that there was a decrease in solubility of 1.10 per cent for the samples prepared in the laboratory and 1.28 per cent for the samples supplied by manufacturers. Manufacturers of blood albumin have found that this material tends to develop insolubility particularly in the presence of moisture. However, in the data presented in tables 2

Table 4.—Analyses made one year apart on samples of spreader held in storage in the laboratory.

Manufacturer	Samples Supplied by Manufacturer				Samples Prepared in Laboratory			
	Moisture		Soluble Solids		Moisture		Soluble Solids	
	1934	1935	1934	1935	1934	1935	1934	1935
	per cent		*per cent*		*per cent*		*per cent*	
1	8.25	8.39	15.1	14.42	4.96	4.38	19.72	18.76
2	8.39	7.97	10.15	8.14	8.96	7.69	22.62	20.72
3	9.84	9.27	19.97	19.18	10.59	9.68	23.04	21.37
4	6.99	5.42	19.09	16.74	6.44	5.32	22.18	21.51
5	2.92	2.28	24.92	24.36	2.83	2.22	24.7	24.38

and 4 there appears to be no definite correlation between the decrease in solubility and the moisture present in the earths used in the different samples. The authors believe that the keeping quality of all the samples may be regarded as satisfactory.—7-27-36.

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FLOODING AS A MEANS OF REDUCING WIREWORM[1] INFESTATIONS

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Search for practical and successful methods of killing wireworms in their soil environment without the use of chemicals constitutes an important problem in economic entomology. The use of insecticides to control wireworms is too expensive for practical purposes on most farms, and this probably explains the great effort that has been made to develop cultural practices to mitigate wireworm damage. Little has been done to find a solution of the problem through an intensive study of the factors influencing the life of wireworms in the soil. There are several reasons for this, such as the inaccessibility of the insects, difficulty in accurately checking their reactions, the fact that in many districts wireworm populations are rather small, and the lack of time or funds with which to conduct the extended investigations necessary. However, with the development of new methods of determining soil populations, together with modern laboratory apparatus for simulating natural environment, these obstacles can be overcome to a great extent.

An intensive three-year study on the biology of wireworms and their ability to thrive under irrigation conditions in the Pacific northwest,

[1] Order Coleoptera, family Elateridae, genus *Limonius;* as used in this paper the term "wireworm" applies only to the larval stage.

undertaken principally at Walla Walla, Wash., disclosed some interesting facts. Experiments based on these discoveries were undertaken first in the laboratory under controlled conditions and later under natural conditions in the field. It was determined that wireworms are definitely affected by the humidity of their soil habitat, and that either a deficiency or an excess of moisture in the soil makes conditions hazardous for them. Investigations are being conducted with both of these natural hazards to ascertain methods by which they can be regulated so as to reduce wireworm populations materially. This paper presents the results of recent studies with flooding as a means of reducing wireworm numbers when considered in conjunction with soil temperature.

Previous investigations.—Few references to flooding as a control method against wireworms have been found in the literature. Miwa & Yanagihara (*7*) stated that "excess humidity causes the wireworm to die" and recommended the complete saturation of the soil for four or five days for the control of wireworms (mainly *Melanotus tamsuyensis* Bates) on sugar cane plantings in Formosa. Calvino (*2*) described the planting of tobacco seedlings in trenches filled with water as a new method of preventing wireworms (*Conoderus* spp.) from attacking tobacco in Cuba. This procedure can hardly be classed as flooding and would not be an effective control measure against *Limonius* spp. in the western irrigated districts of the United States. Other investigators state that flooding fails, or that it is of little avail. As early as 1845 Curtis (*4*; *5*, p. 186) reported that wireworms lived at least four days in water. He stated that "if a field were laid under water for a much longer period [than 4 days], it would not destroy them." Cameron (*3*) stated that "larvae of *Agriotes lineatus* L. were kept alive in water for six days but that they died after seven to eight days' immersion." Hyslop (*6*) concluded that "flooding land where irrigation is practiced would be of little avail unless long continued, as we have records of severe outbreaks of wireworms on land in Indiana that is annually overflowed by the rivers." Baudys (*1*) found that *Agriotes* were driven down by the water and later returned to the surface. The experiments reported by Strickland (*8*) showed that young wireworms of *Ludius aereipennis* Kby. could be submerged in tap water for six weeks without a single mortality. Thomas (*9*) has saturated soil containing larvae of *Limonius* (*Pheletes*) *agonus* Say and has removed most of them alive at the end of two weeks.

These negative results of earlier workers show the extreme resistance of wireworms to drowning. Apparently many entomologists have believed that flooding would not produce the desired result. However, in all of these references no mention has been made of the possible contributing effect of temperature or the season of the year in which flooding should be carried on.

Experimental work.—The two most important wireworms occurring in the irrigated lands of the Pacific slope were used in these experiments, the sugar beet wireworm, *Limonius* (*Pheletes*) *californicus* Mann., and the Pacific coast wireworm, *L. canus* Lec. No significant differences in the reactions of these species to submergence were noted. All stages and sizes of wireworms, except eggs, were used or encountered in the field

during the investigations. There is no evidence that the various stages differ in their resistance to drowning. In the laboratory experiments healthy wireworms recently collected from the field were used and their mortality was practically zero when they were confined singly in damp soil with food during the period of the experiment. In the field experiments the wireworm populations of the plots were checked before and after flooding, as were also the populations of adjoining unflooded areas.

Laboratory studies.—Submergence studies with wireworms were conducted in the laboratory during 1932, 1933 and 1934. In the preliminary investigations the wireworms were submerged singly in open vials of tap water and were held at certain constant temperatures for various periods of time. The time-temperature-mortality curves for submerged wireworms were thus determined. Later experiments consisted in sub-

Fig. 1.—Effect of temperature on the time necessary to kill 100 per cent of the wireworms submerged in water alone in the laboratory.

Fig. 2.—Effect of temperature on the time necessary to kill 100 per cent of the wireworms submerged under soil and water in the laboratory.

merging wireworms, and also the adult beetles, singly in vials of soil and water at certain temperatures and thereby obtaining the time-temperature-mortality curves as in the previous experiments.

Wireworms Submerged in Water Alone.—Groups of 20 wireworms, each individual wireworm placed in a 25 by 100 mm. vial of water, open at the top, were held in constant-temperature cabinets at temperatures ranging from 50 to 86° F. Each group was examined about once a week until all the wireworms showed evidence of decomposition and failed to recover after being taken out of the water.

The time required to kill all 20 wireworms is shown graphically in fig. 1, each temperature experiment being the average of four tests.

It will be seen that the survival of wireworms in water decreased with a rise in temperature. At 50 to 59° F, wireworms lived in water alone for over a year, but at 81.5° F and above, none of the insects survived after approximately one month of submergence.

Wireworms Submerged in Soil under Water.—In the second

series of tests the wireworms were placed singly in the bottom of 25 by 100 mm. vials half full of soil, after which the vials were filled with water and left uncovered. Groups of 20 wireworms were again held in constant-temperature cabinets ranging from 50 to 86° F. One group exposed at each temperature was removed each day and placed on moist blotters in closed tins at room temperature. The time required to kill all 20 wireworms is shown graphically in fig. 2.

These experiments show that wireworms were killed more quickly in water and soil than in water alone. Their period of survival in the flooded soil at 81.5° F was only one-sixth as long as for wireworms submerged in water alone. Complete explanation of this fact is not possible at this time. Probably oxygen deficiency and carbon dioxide accumulation at high temperatures in saturated soil are important factors contributing to the short duration of the life of wireworms living therein. The taking in of soil salts with the water is possibly also a lethal factor. The time required to drown wireworms held in soil and water is much shorter at high temperatures than at low temperatures.

Fig. 3.—Soil cages for wireworm studies, showing a flooded cage at lower right.

WIREWORM ADULTS SUBMERGED IN SOIL UNDER WATER.—A small series of submergence tests was conducted with adult wireworm beetles in soil. The procedure was the same as that used in the previous tests. Groups of 10 adults, confined singly in vials of soil and water, were held in constant-temperature cabinets ranging from 59 to 86° F. The time required to kill 100 per cent of the adults was seven days at 77° F or above, and 14 days at 68° F, but only 30 per cent were killed in 14 days at 59° F.

The results of this experiment approach very closely those obtained with wireworm larvae, indicating that high temperatures in flooded soil affect the metabolism of adults and larvae alike.

Field tests.—Discovery of the importance of temperature as a factor affecting the survival of submerged wireworms led to field investigations of flooding during the summers of 1932 and 1933.

Flooding of Soil Cages.—The first tests were made in soil cages, fully exposed to the sun, in the laboratory field, fig. 3. These cages were constructed of 22-gauge galvanized-iron sides, reinforced with 1 by 3-inch wooden strips fastened on the outside upper edges. They were made 4 feet wide, 10 feet long and 18 inches deep, with a partition through the middle. After the cages had been placed in the soil flush with the surface, a thin layer of porous cement was poured over the soil at the bottom to

Fig. 4.—Field plots used in experiments with flooding as a control for wireworms.

prevent the wireworms from escaping. This cement layer did not interfere seriously with the drainage of the cages. The cages were filled with sterilized soil, free from wireworms.

Several tests were carried out for periods of one, two, three, four, seven and 23 days. Large numbers of wireworms were placed in the soil of the cages at depths of 3, 6, 9 and 12 inches. The cages were immediately flooded with water from a garden hose, the faucet being set to maintain a 2-inch layer of water over the soil surface during the period of test. Soil temperatures at three depths under the water were obtained with a recording thermometer and air temperatures in the shade 4 feet above the water were obtained from a thermograph. Average maximum, minimum and mean temperatures only are used. After the flooding, the soil in the cages was taken up and washed through screens to recover the live and dead wireworms.

Results of these field-cage flooding tests are given in table 1. It is seen that from 93.5 to 98.7 per cent of the wireworms were killed in seven days of flooding with mean soil temperatures at 69.9 and 73.3° F, respectively. Flooding soil four days at mean soil temperatures of 75° F killed 87.5 to 92.5 per cent of the wireworms present. Mean soil temperatures of 73.1 to 75.8° F were not sufficient to kill more than 18 to 23.3 per cent of the wireworms in one day.

FLOODING LARGE FIELD PLOTS.—Tests in the flooding of larger plots, one-sixth to one-half acre, were conducted throughout the summer and early fall of 1932 and 1933, fig. 4. Some of these tests were performed during the hottest part of summer, whereas others were conducted during

Table 1.—Mortality of wireworms as a result of flooding infested soil cages for different periods and at different temperatures.

Period of Flooding		Mean Average Daily Temperature, F		No. Wireworms in Cages	Percentage Wireworm Mortality
No. Days	Dates	Air (Shade)	Soil (0.12 Inches)		
1	July 11–12	76	73.1	332	18.
	July 13–14	77	75.8	381	23.3
2	July 11–13	75	74.3	400	81.8
3	June 14–17	77	72.9	764	89.5
	July 11–14	76	74.8	307	76.9
4	July 11–15	77	75.4	492	92.5
	July 24–28	78	75.1	368	87.5
7	June 15–22	67	69.9	771	93.5
7	July 19–27	73	73.3	2224	94.5
				2000	98.7
23	June 22–July 15	71	72.3	2851	99.9
				2040	99.8

cooler weather. Soil preparation prior to flooding consisted of plowing, leveling and dyking. The sources of water were artesian wells, springs and rivers. The water was maintained continuously at a depth not exceeding 3 inches, since considerable time is required for the sun to heat a deeper layer of water each day. The wireworm populations of the various plots were obtained by washing an equal number of soil samples through screens before and after flooding. The washing method was used because of the impossibility of sifting the wet soil very shortly after the flooding is stopped and also because it enables one to determine the effects of flooding on all sizes of wireworms. The size of the sample was 3 inches square and 1 foot deep (one-sixteenth cubic foot). During the course of these field experiments the square-foot siftings showed in all cases 100 per cent of the wireworm populations in the surface 12 inches, except in one case where 91 per cent were found in the surface 12 inches. Temperatures obtained in some of the fields, however, indicate that wireworms can be killed at a depth of more than 12 inches in flooded soil.

The results of these tests are shown in table 2. It will be seen that from 95.3 to 100 per cent of the wireworms were killed in one week of flooding at mean soil temperatures of 75 to 77.9° F. The percentage of kill was reduced as the temperature was lowered, and this reduction was only partly offset by increasing the period of flooding. Early fall flooding for 24 days with mean soil temperatures of 67.5° F killed only 33.3 per cent of the wireworms, although the adult population was recuced 71 per cent.

Late fall, winter and spring flooding would not appreciably reduce the wireworm population. The only time that flooding could be practiced successfully, at least in the north temperate zone, is in July and August.

Table 2.—Mortality of wireworms as a result of flooding infested field plots for different periods and at different temperatures.

Period of Flooding		Mean Average Daily Temperature, F		No. Wireworms*		Percentage Wireworm Mortality
No. Days	Dates	Air (Shade)	Soil (0–12 Inches)	Before Flooding	After Flooding	
3	July 6–10	71	70.1	5.44	2.24	59.
7	Aug. 11–18	79	77.9	35.2	0.	100.
				38.4	1.2	96.8
				46.1	2.6	94.5
	July 26–Aug. 2	70	75.0	40.96	1.92	95.3
	Aug. 9–16	68	72.3	3.84	.8	79.
10	Aug. 9–19	69	67.1	18.24	4.48	75.5
24†	Sept. 13–Oct. 7	60	67.5	6.	4.	33.3
36	Aug. 25–Sept. 30	63	64.1	6.72	2.24	66.7
210	October–May	44	54 0	1.08	.8	26.

* Average per square foot for the area sampled.
† In this experiment 71 per cent of the hibernating wireworm adults also were killed.

Discussion.—The most significant fact brought out in this investigation is the relation of temperature to the drowning of wireworms. Wireworms are strongly resistant to drowning under normal soil conditions. At soil temperatures below 68° F wireworms can survive beyond the limits of practical flooding, and at less than 60° F they can survive submergence for several months. At temperatures from 54 to 60° F submerged wireworms are sluggish, but they retain sufficient power of locomotion to enable them frequently to crawl out on the soil surface under the water. These facts probably explain the lack of success in previous attempts to kill wireworms by this method.

The reactions of wireworms submerged in soil and water at soil temperatures above 68° F explain in part how they are killed. In these higher soil temperatures the wireworms become inactive within a few minutes after the water has been applied to the soil. Apparently they are unable to move through the soil, and after a few hours' exposure they become very stiff and swollen. The wireworms apparently absorb water in all parts of their bodies, probably as the result of some osmotic reaction. Most individuals recovered from this condition when removed to moist air soon after the swollen condition had developed, but after three days or

more many of the stiff and swollen wireworms decomposed and disintegrated completely.

Reducing wireworm populations by flooding has considerable possibilities of application, especially in the irrigated districts of the western states. These experiments have shown that wireworms can be killed during their active season by means of flooding at soil temperatures as low as 75° F if maintained for a period of one week. The infested soil must be submerged completely with a layer of water not more than 3 inches deep, maintained continuously. In many sections of the Pacific slope the temperatures during July and August are such that flooding operations against wireworms can be conducted practically every year. While the majority of the wireworms used in these experiments were species of *Limonius*, species of other genera were found to have been killed in the field experiments.

The economic value of the reduction in numbers of wireworms resulting from the flooding treatments, as measured by the effect on crops planted later in such fields, is difficult to determine accurately. Any surviving wireworms are located too deeply in the soil late in the summer to cause appreciable damage to crops planted that season, and during the following season the damage will depend upon those soil conditions which affect wireworm distribution in the soil and upon the type of crop planted.

Summary.—The results of three seasons' investigations pertaining to the killing of wireworms by flooding the infested soil are presented.

Laboratory experiments with wireworms submerged in water alone showed that temperature is an important factor in the death of wireworms, and when soil was added to the water the wireworms were killed in about one-sixth the time required when water alone was used. When submerged under soil at 77° F, 100 per cent of the wireworms were killed in seven days. Results with adult beetles were practically the same as those with larvae.

Outdoor cage experiments in the sun demonstrated that a large percentage of the wireworms could be killed within a week or less by flooding when the mean soil temperature was between 70 and 76° F.

Larger field tests further demonstrated the possibility of flooding as a means of reducing wireworm populations. From 95 to 100 per cent of the wireworms were killed within one week at a mean submerged soil temperature of 75° F or above.

Flooding as a means to reduce wireworm numbers offers practical possibilities under conditions where high soil temperatures (70° F or above) can be maintained for several days during the year, and where the soil topography and water supply render the adoption of this method practicable.—7-17-36.

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TOXIC ACTION OF NICOTINES, NORNICOTINES AND ANABASINE UPON *APHIS RUMICIS* L.[1]

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This is a report upon the toxic action of three N-heterocyclic compounds, *dl*-α-nicotine, *dl*-α-nornicotine and *dl*-β-nornicotine, which have not previously been examined for their action on insects. The resuts similarly obtained with *l*-β-nicotine (natural nicotine), with *dl*-β-nicotine (racemic nicotine) and with anabasine (*l*-β-pyridyl-α-piperidine) are included for certain comparations.

The investigation upon which this publication is based is a continuation of a study of N-heterocyclic compounds, a part of which was reported in 1933 (*5*). The compounds resulting from a chemical study of nicotine (*3, 4*) have afforded another opportunity to compare the toxic effectiveness for insects of the α and β linkages in the pyridyl derivatives, this time in the pyridyl pyrrolidines instead of the pyridyl piperidines The availability of synthetic *dl*-β-nicotine enabled the writers to reexamine its toxicity and to obtain a better value for its median lethal concentration.

The experiments, made at Ames, Iowa, covered the periods from February 10 to May 19, 1934, and from March 29 to May 24, 1935.

Materials and methods.—The test insects were the adult wingless agamic females of the bean aphis, *Aphis rumicis* L., reared in the greenhouse on dwarf nasturtium plants.

The nicotine and nornicotine compounds, prepared by Craig (*3, 4*), proved upon analysis to be highly pure products. The sample of pure anabasine base was kindly donated by Mr. O. A. Nelson of the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, who has studied the physical constants of this alkaloid (*12*).

The method of applying the compounds was essentially that previously described (*5*). The solutions, which always contained .25 per cent (grams per 100 cc. of solution) of sodium oleate, were applied as a fine

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spray at a pressure of 2.5 pounds per square inch and a nozzle delivery of .56 to .76 gram (average .66 gram) of solution in 20 seconds, this being the time of application used in all the tests. Variations of nozzle delivery within this range appeared to be unimportant. The insects were sprayed on cotton flannel from which they were transferred to nasturtium leaves by means of a camel's-hair brush, wet with the spray solution. Here they remained until they were examined for the percentage of mortality 24 hours later.

The controls were of two kinds. Samples of 10 aphids, drawn at random from the population at frequent intervals, were subjected to the same treatment as the experimental samples, except that they were not sprayed. Other samples, obtained in the same way, were sprayed with

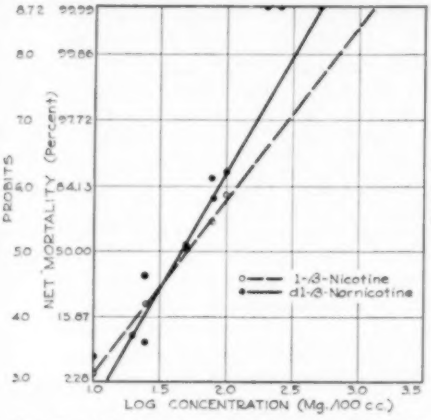

Fig. 1.—The toxicity of *l*-β-nicotine (natural nicotine) and *dl*-β-nornicotine to adult *Aphis rumicis*. Each point in this and the succeeding figures represents the mean net percentage of mortality of six samples of 10 insects each. Time constant, 24 hours.

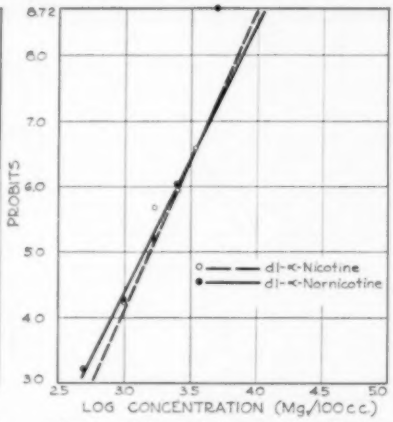

Fig. 2.—The toxicity of *dl*-α-nicotine and *dl*-α-nornicotine to *Aphis rumicis*. Time 24 hours.

.25 per cent sodium oleate solution. The unsprayed samples, which provided a check on the normal viability of the population and the effects of manipulation other than spraying, gave group mortalities which varied from 1.1 to 3.3 per cent, the average being 2.6 per cent. The chi-square (χ^2) test showed that these group mortalities, individually and collectively, were no more variable than would be expected from random sampling.

The mortalities of the samples treated with .25 per cent sodium oleate solution varied from 10. to 23.3 per cent, the mean for the 29 samples being 13.8 per cent. The net mortality (mortality for the sodium oleate solution only) was 11.6 per cent. The χ^2 values corresponded with probabilities greater than .05 and, as in the unsprayed checks, were adequate.

Results.—The results are shown in the accompanying figures as points along regression lines. The regression lines were plotted according to the method of Bliss (*1*) with the ordinates as probits (probability units) and the abscissas as logarithms of the concentrations in milligrams per 100 cc.

of solution. Each line is the calculated first approximation of a provisional regression line which was fitted by eye to the points representing the experimental data. The experimentally derived points of several of the compounds followed so closely a rectilinear trend that little difference existed between the eye-fitted and the calculated lines; but the method has been valuable in establishing the line of best fit for those cases in which the points were scattered and in fixing the limits of error above and below the calculated line. A better fit to the experimental points could have been obtained by calculating a second approximation from the first but for present purposes this has not seemed necessary.

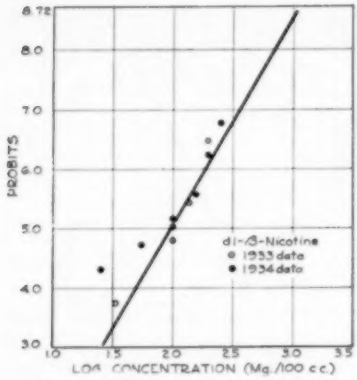

Fig. 3.—The toxicity of *dl*-β-nicotine (racemic nicotine) to *Aphis rumicis*. Time 24 hours.

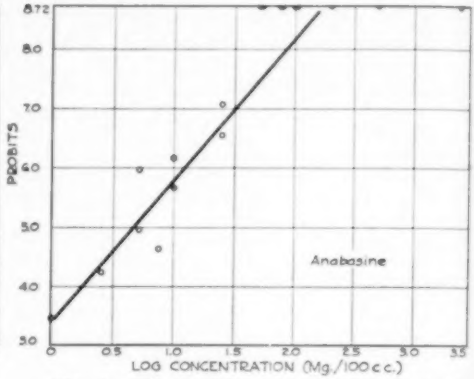

Fig. 4.—The toxicity of anabasine to *Aphis rumicis*. Time 24 hours.

The χ^2 test indicates that the observed mortalities for natural nicotine, fig. 1, agree within the limits of error with the calculated curve ($\chi^2 = .932$, $N = 3$, $P = .80–.90$). For β-nornicotine, however, a greater departure from the fitted line is evident, and the χ^2 value is below expectation ($P = < .01$). If the limits of error for natural nicotine are calculated, that is, if the zone on either side of the fitted line is delimited which defines that line within 95 chances in 100, three of the mortality points for β-nornicotine fall within the zone, three points fall on its upper margin, and only two points lie far outside the zone. The two compounds, therefore, are similar if not alike in toxicity to *Aphis rumicis*.

The calculated lines for α-nicotine and α-nornicotine, fig. 2, agree so closely that the toxicities of the two compounds, within the limits of error stated above, may be considered identical.

The 1933 mortality data for racemic nicotine (*5*) is accepted as best expressing the toxicity of this compound to *Aphis rumicis*, fig. 3. The χ^2 test reveals a satisfactory agreement between the observations and the calculated line ($\chi^2 = 7.834$, $N = 3$, $P = .05$ approximately). A reexamination of racemic nicotine in 1934 furnished less concordant mortalities, which, with two exceptions however, fall within the above recognized limits of error. The concentration of 96 mg. per 100 cc., corresponding

Table 1.—Concentrations of nicotines, nornicotines and anabasine for 50 and 100 per cent mortalities of Aphis rumicis.

Compound	50 Per Cent Net Mortality *mg. per 100 cc.*	100 Per Cent Net Mortality *mg. per 100 cc.*
l-β-Nicotine	49	1185
dl-β-Nornicotine	45	490
dl-α-Nicotine	1496	10960
dl-α-Nornicotine	1514	10470
dl-β-Nicotine	96	1259
Anabasine	5	166

with the point of 50 per cent mortality, is considered a better estimate than that of 120 mg., published earlier (*5*).

The data for anabasine, fig. 4, based upon tests made in 1934 and 1935, are not in satisfactory agreement with the calculated regression line although six of the eight points, representing net mortalities below 95 per cent, fall within the calculated limits of error. The data are sufficient to show that anabasine is much more toxic to this aphid than the other compounds used in this investigation.

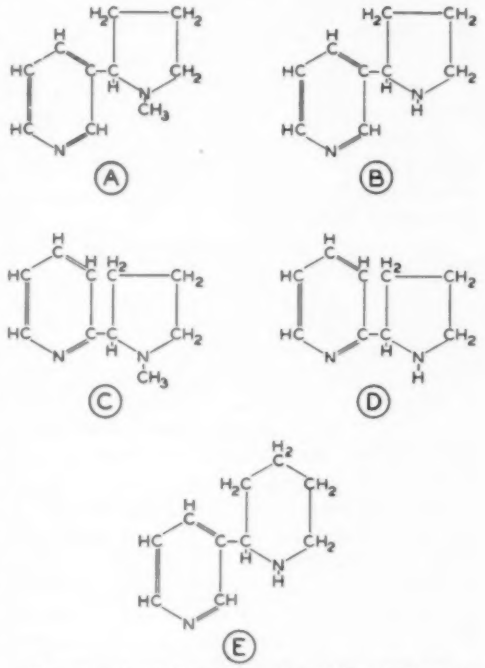

Fig. 5.—A, β-Nicotine. B, β-Nornicotine. C, α-Nicotine. D, α-Nornicotine. E, Anabasine.

Table 1 gives the concentrations of the compounds which correspond to 50 per cent and approximately 100 per cent net mortalities. The latter were obtained by extrapolation of the calculated regression lines to the probit for 99.99 per cent mortality. From the data at hand it is not to be expected that the concentrations for 100 per cent mortality will agree as closely as those for 50 per cent mortality because slight differences in position and slope of the lines near the midpoints are reflected in larger differences near their upper and lower limits. The values in the table were read from graphs on millimeter cross-section paper and are somewhat more exact than those which can be obtained from the graphs given here.

Discussion.—It is evident from fig. 1 that *dl*-β-nornicotine and natural nicotine are of approximately equal toxicity. The former compound dif-

fers structurally from natural nicotine only in the absence of a methyl group on the nitrogen of the pyrrolidine nucleus, fig. 5. Apparently the presence or absence of a methyl group in this position of a pyridyl pyrrolidine is not essential for the toxic action of the compound upon *Aphis rumicis*.[2]

Macht & Davis (*11*) observed that β-nornicotine was more toxic for certain vertebrates (cats, rats) than natural nicotine, whereas for some other vertebrates it was less toxic. Ehrenstein (*7*) reports the optical isomer, *l*-β-nornicotine, less active (tonus of frog muscle; blood pressure and heart activity of the cat) though resembling natural nicotine in its effects.

In contrast to the β-compounds, the α derivatives in this series are much less toxic. The results agree with an earlier conclusion reached from a study of certain pyridine and piperidine derivatives, that the αβ and βα groupings are more toxic than those in other positions (*13*). Furthermore, this conclusion is supported by the work of Macht & Davis (*11*) on a number of vertebrates for which α-nicotine and α-nornicotine were less potent than the corresponding β-compounds. The prediction of Dingemanse (*6*) that α-nicotine would have the same toxic properties as β-nicotine is not fulfilled by the results of these experiments.

The values for *dl*-β-nicotine, table 1, show a median lethal concentration of about one-half that for *l*-β-nicotine, furnishing an argument for the view that the *laevo* fraction is largely responsible for the toxic action of racemic β-nicotine.

Anabasine was included in this investigation in order to compare the alkaloid base directly with natural nicotine. The recent studies by Garman (*8*, *9*) and by Ginsburg, Schmitt & Granett (*10*) on *Aphis rumicis* were made with solutions of anabasine sulfate. Anabasine base is decidedly more toxic to *Aphis rumicis* than natural nicotine and β-nornicotine. The results in general confirm Garman's results with anabasine sulfate.

Unfortunately, neonicotine (*dl*-β-pyridyl-α-piperidine) was not available for comparison with anabasine, but from previous experience (*13*) it should be somewhat less toxic to this aphid than the latter compound.

Among a large number of pyridine and pyrrol derivatives which have been tested for insecticidal properties, only two, anabasine and its optically inactive form, neonicotine, aside from natural nicotine, are outstanding. This investigation adds a third, *dl*-β-nornicotine, more closely related in structure than the others to natural nicotine. Ehrenstein (*7*) claims to have found the optical isomer, *l*-β-nornicotine, in tobacco and possibly it will be discovered in other plants.[3]

Summary and conclusions.—*dl*-β-Nornicotine, *dl*-α-nicotine, *dl*-α-nornicotine, *dl*-β-nicotine (racemic nicotine) and anabasine (*l*-β-pyridyl-

[2] Campbell, Sullivan & Smith (*2*) report methyl anabasine somewhat less tonic than anabasine to mosquito larvae.

[3] As this goes to press, papers by Hicks & LeMessurier (Austral. Jour. Exp. Biol. Med. Sci. 13(3):174–88, 1935) and Hicks (Ibid. 14(1):39–43, 1936) have come to our attention, which report the discovery of *d*-nornicotine in the leaves of the Australian solanaceous plant *Duboisia kopwoodii*, and describe its toxicity and physiological action upon several vertebrate animals. It is said to be more toxic than nicotine to the rat, and though similar in action yet there are quantitative and qualitative differences.

α-piperidine) were compared in toxicity with *l*-β-nicotine (natural nicotine). The solutions of the bases in .25 per cent sodium oleate solution were applied in a fine spray to adult *Aphis rumicis* under standardized conditions. The order of toxicity, based upon the median lethal concentrations in mg. per cc. of solution is: Anabasine > *l*-β-nicotine = *dl*-β-nornicotine > *dl*-β-nicotine > *dl*-α-nicotine = *dl*-α-nornicotine. The presence or absence of a CH_3 group on the pyrrolidine nitrogen of a pyridyl pyrrolidine is not essential for the toxic action of the compound to *Aphis rumicis*. This may or may not be true for certain vertebrate animals and by inference for other insects. The compounds with linkage at the β-position of the pyridine nucleus are the most toxic in this series as they have previously been found to be in the pyridyl piperidine series. This relation between the β-position and toxicity in these pyridine derivations may prove to be fairly general for it seems to hold true for certain vertebrates as well as for aphids. Racemic nicotine is about one-half as toxic as natural nicotine, the *laevo* fraction probably being largely responsible for its action on this aphid. Anabasine is considerably more toxic than the other compounds studied in this investigation, and it is probably somewhat more toxic than neonicotine.—9-16-36.

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The Arkansas plant board adopted regulations on July 9 requiring analyses of seeds of alfalfa, lespedeza, clover and vetch for the presence of dodder or of the vetch weevil. Fees are required of seedsmen shipping into or within the state.

ARSENICAL SUBSTITUTES

II. SOME RELATIONSHIP BETWEEN MOLECULAR STRUCTURE AND TOXICITY OF ORGANIC COMPOUNDS TO THE SILKWORM, *BOMBYX MORI*[1]

JOSEPH M. GINSBURG and CHESTER J. CAVALLITO, *New Jersey Agricultural Experiment Station, New Brunswick*

A total of 121 organic compounds, selected mostly from benzene derivatives, were tested as stomach poisons against silk moth larvae by the dust method, as described in the first paper of this series (*1*). All the chemicals were insoluble in water. The dusts were prepared by mixing 10 per cent of the chemical to be tested with 90 per cent kaolin by

Table 1.—Toxicity of 26 organic compounds to silk moth larvae.

No.	Name of Chemical	Formula	Total No. Insects	Per Cent Dead After Three Days
171	phenothiazine	$C_6H_4NHC_6H_4S$	60	100
218	thioacetanilide	$C_6H_5NHCSCH_3$	80	95
305	d-camphor oxime	$C_{10}H_{16}NOH$	50	90
194	methyl undecyl ketone	$C_{11}H_{23}COCH_3$	80	90
293	diphenyl nitrosoamine	$(C_6H_5)_2NNO$	50	75
287	p-nitrophenetole	$C_6H_4NO_2OC_2H_5$	50	63
94	dimethyl glyoxime	$(CH_3CNOH)_2$	50	55
233	triazene, 1, 3-diphenyl	$C_6H_5N=NNHC_6H_5$	60	45
318	coumarin	$C_6H_4CH\text{-}CHCOO$	40	40
254	d-diphenyl semicarbazide	$(C_6H_5)_2NH_2N\ CONH$	40	40
228	benzene azo diphenyl amine	$(C_6H_5)_2N_2C_6H_5$	40	40
275	formyl diphenyl amine	$(C_6H_5)_2N\ CHO$	30	40
221	phenyl thiohydantoic acid	$C_6H_5NH\text{-}CS\text{-}NHCH_2COOH$	30	40
257	lepidone	$C_{10}H_9N$	30	35
214	phenyl benzothiazole	$C_6H_4SC(C_6H_5)N$	30	35
216	thiophenyl acetamide	$C_6H_5SCH_2CONH_2$	30	35
189	p-phenylene diamine	$C_6H_4(NH_2)_2$	30	30
253	p-ethoxy diphenyl	$C_6H_5OC_2H_5C_6H_4$	30	25
271	m-tolyl hydrazin	$CH_3C_6H_4NH\ NH_2$	30	25
234	o-tolyl thiourea	$CH_3C_6H_5NH\text{-}CS\text{-}NH_2$	30	20
269	p-hydrazinobenzoic acid	$C_6H_5(NH)_2C_6H_4COOH$	30	20
237	N-phenyl pyrrole	$C_6H_5N(CH)_4$	30	20
164	thiocarbanilide	$(C_6H_5NH)_2\ CS$	30	20
304	α-benzil dioxime	$(C_6H_5)_2(CNOH)_2$	30	20
246	phenyl semicarbazide	$H_2N\text{-}N(C_6H_5)CO\text{-}NH_2$	30	10
201	triphenyl guanidine	$(C_6H_5NH)_2CN\ C_6H_5$	30	10
	Check, lead arsenate	$PbHAsO_4$	100	100
	Check, kaolin		120	0

weight. With each series of tests a dust containing 10 per cent acid lead arsenate was also used for comparison.

Method of testing.—Ten vigorous larvae in the third instar were em-

[1] Paper of the Journal series, New Jersey Agricultural Experiment Station, Department of Entomology.

Table 2, Part I.—Ninety-four organic compounds showing no toxicity to silk moth larvae.

No.	Name of Chemical	Formula
227	acetyl p-anisidine	$CH_3OC_6H_4NH\text{-}CO\text{-}CH_3$
283	acetyl m-anisidine	$CH_3OC_6H_4NH\text{-}CO\text{-}CH_3$
240	acetyl a-naphthylamine	$C_{10}H_7NH\text{-}CO\text{-}CH_3$
223	acetyl m-phenetidine	$CH_3\text{-}CO\text{-}NH\text{-}C_6H_4\text{-}OC_2H_5$
282	acetyl p-toluidine	$CH_3\text{-}C_6H_4\text{-}NH\text{-}CO\text{-}CH_3$
255	allyl thiourea	$CH_2{=}CH\text{-}CH_2\text{-}NH\text{-}CS\text{-}NH_2$
242	2-amino-5-azoanisole	$C_6H_4NC_6H_3N(NH_2)OCH_3$
284	p-amino phenol oxalate	$(C_6H_4OH\ NH_2COOH)_2$
270	n-amyl phthalate	$C_6H_4(COO\text{-}CH_2\text{-}(CH_2)_3\text{-}CH_3)_2$
235	benzoyl a-naphthylamine	$C_{10}H_7NH\text{-}CO\text{-}C_6H_5$
291	benzoyl piperidine	$C_5H_5\text{-}CO\text{-}N\ C_5H_{10}$
248	benzyl iso thiourea hydrochloride	$C_6H_5CH_2\text{-}S\text{-}C(=NH)\ NH_2\text{-}HCl$
280	benzyl a-naphthyl ether	$C_6H_5CH_2\text{-}O\text{-}C_{10}H_7$
208	benzyl phthalate	$(C_6H_5CH_2\text{-}O\text{-}CO)_2C_6H_4$
249	benzyl o-toluidine	$C_6H_5\text{-}CH_2\text{-}NH\text{-}C_6H_4\text{-}CH_3$
272	iso-butyl caproate	$CH_3(CH_2)_4\text{-}COO\text{-}CH_2\text{-}CH\text{-}(CH_3)_2$
266	n-butyl caproate	$CH_3(CH_2)_4COOC_4H_9$
263	N-butyl o-methoxybenzoate	$C_6H_4(OCH_3)\ COOC_4H_7$
229	n-butyl phthalic acid	$HO\ OC\ C_6H_4\text{-}CO\ OC_4H_9$
302	2 hydroxy quinoline	$HO\ C_9H_6N$
268	β-chloro-anthraquinone	$C_6H_4{=}(C{=}O)_2{=}C_6H_3Cl$
278	4-chlorophenyl-4 toluene sulfonate	$C_6H_4ClSO_3C_6H_4CH_3$
279	2-chlorophenyl-4 toluene sulfonate	$C_6H_4ClSO_3C_6H_4CH_3$
317	cinnamyl acetophenone	$C_6H_5(CH)_4C_6H_5CO$
206	cyclohexyl phthalate	$C_6H_4(COOC_6H_{11})_2$
244	diacetyl benzidine	$(CH_3\text{-}CO\text{-}NH\text{-}C_6H_4)_2$
281	p, p′-diamino diphenyl methane	$NH_2C_6H_4\text{-}CH_2\text{-}C_6H_4NH_2$
238	diamyl hydroquinone	$(CH_3\text{-}CH_2\text{-}C(CH_3)_2)_2C_6H_2(OH)_2$
256	dibenzoylethylene diamine	$(C_6H_5CONHCH_2)_2$
264	2, 4-dichlorophenyl-4 toluene sulfonate	$C_6H_3Cl_2SO_3C_6H_4CH_3$
193	diethyl ammonium diethyl dithio carbamate	$SCN(C_2H_5)_2SNH_2(C_2H_5)_2$
267	diethyldithio oxalate	$(CO\text{-}S\text{-}C_2H_5)_2$
292	p-dimethyl amino azo benzene	$(CH_3)_2NC_6H_4N{=}N\text{-}C_6H_5$
247	p-dimethyl amino benzal rhodanine	$C_6H_4N(CH_3)_2CONHCH(CS)_2$
210	dimethyl ammonium dimethyl dithio carbamate	$SCN(CH_3)_2SNH_2(CH_3)_2$
209	dimethyl dihydro resorcinol	$C_6H_4(OH)_2(CH_3)_2$
243	N, N′-dimethyl, N,N′-diphenylurea	$(C_6H_5N(CH_3))_2C{=}O$
288	diphenyl quanidine	$HN{=}C(NHC_6H_5)_2$
290	diphenyl a-naphthyl carbinol	$(C_6H_5)_2(C_{10}H_7)C\ OH$
215	di-p-phenetylurea	$(C_2H_5O\ C_6H_4NH)_2C{=}O$
198	diphenyl piperazine	$C_6H_5N{=}(CH_2\text{-}CH_2)_2{=}N\text{-}C_6H_5$
226	diphenyl thio carbazide	$(H_2N\text{-}N(C_6H_5)\text{-})_2C{=}S$
207	di-p-tolylhydrazo dithio dicarbonamide	$(C_6H_4CH_3NHCSNH)_2$
241	β-ethoxy ethyl phthalate	$C_6H_4(CO\text{-}O\text{-}CH_2\text{-}CH_2\text{-}O\text{-}C_2H_5)_2$
199	ethylene dicaprate	$(C_9H_{11}COO)_2C_2H_4$
204	ethylene diphthalimide	$(C_6H_5COCONH\ CH_2)_2$
220	furfuramide	$(C_5H_4O)_3N_2$
219	α-furil dioxime	$(C_4H_4OCNOH)_2$
191	furoic acid	$C_4H_3O\ COOH$
252	furoin	$C_4H_3O\ CHOH\text{-}CO\ C_4H_3O$
277	hydroquinone monobenzyl ether	$HO\text{-}C_6H_4\text{-}O\text{-}CH_2C_6H_5$

ployed for each test. Each chemical was run through at least two tests. If none of the insects died within three days of feeding on the dusted mulberry leaves the compound was classified as nontoxic. When a kill of

Table 2, Part II.—Ninety-four organic compounds showing no toxicity to silk moth larvae.

No.	Name of Chemical	Formula
303	p-hydroxy azo benzene	H O $C_6H_4N=N\ C_6H_5$
258	p-hydroxy benzo phenone	HO C_6H_4-CO-C_6H_5
259	3-hydroxy-2-naphthoic acid	HO-$C_{10}H_6$COOH
297	8-hydroxy quinoline	HO C_9H_6N
320	β-methoxy ethyl carbonate	$OC(OCH_2CH_2OCH_3)_2$
319	β-methoxy ethyl phthalate	$C_6H_4(COOCH_2$-$CH_2OCH_3)_2$
245	β-methyl anthraquinone	$C_6H_4(CO)_2C_6H_2CH_3$
274	methyl quanidine sulfate	$C_4H_{16}N_6O_4S$
265	α-methyl α-phenyl hydrazine	$C_6H_5N(CH_3)\ NH_2$
260	3-methyl-5-pyrazolane	NH-N=C(CH_3)-CH_2-CO
200	β-naphthalene sulfonic acid	$C_{10}H_7SO_3H$
295	naphthionic acid	$C_{10}H_6(SO_3H)\ (NH_2)\ \frac{1}{2}\ H_2O$
299	β-naphthoic acid	$C_{10}H_7COOH$
301	1, 4-naphthoquinone	$C_{10}H_6O_2$
296	oxamide	$CONH_2$-$CONH_2$
222	phenanthraquinone	$C_6H_4=(CO)_2=C_6H_4$
316	β-phenyl ethyl cinnamate	$C_6H_5(CH)_2COO(CH_2)_2C_6H_5$
289	1-phenyl, 3 methyl, 5 pyrazolane	N-(C_6H_5)N=C(CH_3)-CH_2-CO
202	N-phenyl-β-naphthylamine	C_6H_5-NH-$C_{10}H_7$
315	phenyl salicylate	HO-C_6H_4-$COOC_6H_5$
298	iso-phthalic acid	$C_6H_4\ (COOH)_2$
286	phthalimide	$C_6H_4=(CO)_2=N$-H
231	propenyl guaiacol	$C_6H_3OHOCH_3CH=CHCH_3$
190	pyrocatechin	$C_6H_4(OH)_2$
273	quinolyl hydrazine	C_9H_7N-NH-NH_2
197	rhodanine	SC-NH-CO-CH_2-S
306	sebacic acid	$COOH(CH_2)_8COOH$
276	tetraiodophthalicanhydride	$C_6I_4(CO)_2O$
251	tetramethyl diamino benzhydrol	HO CH $(C_6H_4N(CH_3)_2)_2$
196	tetramethyl diamino benzophenone	$(CH_3)_2N\ C_6H_4CO$-C_6H_4-$N(CH_3)_2$
230	tetramethyl diamino diphenyl methane	$H_2C(C_6H_4N$-$(CH_3)_2)_2$
195	tetramethyl thiouram disulfide	(-S-CS-N-$(CH_3)_2)_2$
192	thianthrene	$C_{12}H_8S_2$
224	thioacetamide	CH_3-CS-NH_2
205	thiobarbituric acid	S=C(-NH-CO-)$_2CH_2$
203	thio β-naphthol	$C_{10}H_7$S-H
217	thiotrimethyl acetamide	$C(CH_3)_3CSNH_2$
300	p-toluene sulfonylaniline	$CH_3C_6H_4SO_2NH$-C_6H_5
211	o-tolylthiosemicarbazide	$CH_3C_6H_4N(NH_2)$-CS-NH_2
232	triphenyl carbinol	$(C_6H_5)_2$C-OH
225	triphenyl thiophosphate	$(C_6H_5)_3$-S-PO_3
212	trithiomethylene	$(CH_2S)_3$
213	trithiophenyl phosphate	$(C_6H_5S)_3PO$

10 per cent or higher was obtained in the first test with a given chemical, the testing was repeated several times to substantiate the toxicity of the compound. Upon completion of the tests all the compounds were divided into two groups: one, toxic chemicals, the results of which are presented in table 1, arranged in descending order of toxicity, and two, nontoxic chemicals, given alphabetically in table 2. The percentage dead in table 1 represents an average of the repeated tests. The number of tests conducted with each chemical can be obtained by dividing the total number of insects by 10.

Discussion of results.—An analogy of the compounds tested reveals the following outstanding molecular features: 109 chemicals contain one or more benzene rings in the molecule; 65 contain various nitrogen groups such as amines (=NH), (NH_2), nitro groups (NO_2), azo groups (N:N) and oximes (=CNOH); 56 chemicals contain no nitrogen; 31 contain sulfur groups such as alkyl sulfides (R-S), (=R-SC), thioethers (R-S-R), thioacids (R-COSH), etc.; 19 compounds contain both sulfur and nitrogen groups in the molecule.

The results in table 1 indicate that of all the organic compounds tested, 26 possess varying degrees of toxicity, of which only seven produced mortality of silkworms from 55 to 100 per cent. The other 19 chemicals ranged in toxicity from 10 to 45 per cent dead larvae after three days.

Of the 26 "toxic" chemicals, 23 contain nitrogen groups in the molecule, while only three contain no nitrogen. Of the toxic groups containing nitrogen, seven also contain sulfur in the molecule. Of the 13 chemicals ranking higher in toxicity than 40 per cent, table 1, nine contain amino or hydroxyl amino groups in the molecule.

It is rather striking that out of 56 compounds containing no nitrogen only three, or approximately 5 per cent, should possess toxicity, while out of 65 chemicals containing nitrogen, 23, or 35 per cent, should be toxic. Furthermore, of the seven compounds ranking high in toxicity, six contain nitrogen groups, namely, thioacetanilide, phenothiazine, d-camphor oxime, diphenyl nitrosoamine, p-nitrophenetole, and dimethyl glyoxime, while only one, namely methyl undecyl ketone, contains no nitrogen. It is also worth noting that the two chemicals which proved highest in toxicity to silkworms, phenothiazine (100 per cent) and thioacetanilide (95 per cent) contain nitrogen and sulfur in the molecule, the nitrogen in both instances being in the form of amino groups, while the sulfur is in the form of thio groups.

If the silkworm may be taken as an indicator in insect toxicology, these results definitely suggest that water-insoluble organic compounds are apt to be of higher toxicity to insects when they contain amino groups in their molecule and still more so when sulfur is also present.

Summary and conclusions.—The insecticidal properties of 121 water-insoluble organic compounds were tested as stomach poisons against silk moth larvae. Only 26 chemicals possessed any toxicity whatsoever, while seven chemicals produced mortality of from 55 to 100 per cent after three days. The results suggest that organic compounds are apt to be of higher toxicity to chewing insects when they contain both amino and thio groups in the molecule.—9-15-36.

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The federal quarantine which prohibits the movement of soil from Hawaii and Puerto Rico to other parts of the United States on account of insect pests, including white grubs and termites, was revised effective September 1 to contain a provision for the retention under adequate safeguards of ornamental plants in soil on board at mainland ports. Landing of plants in soil on the mainland is still prohibited.

FUNDAMENTAL PRINCIPLES AND PRACTICES IN EXTENSION APICULTURE

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Extension work in apiculture differs in no essentials from other phases of agricultural extension work excepting in the subject matter. The slogan, "Helping others to help themselves," often used by writers and speakers on extension programs, applies in every detail to the activities of the extension specialist in beekeeping. Without the application of this principle, extension work must fail in its purpose, and the work of the specialist will be lacking in lasting results. To accomplish the ends to be sought in this work, the specialist must have personality and ability to present his subject matter to the beekeepers and, many times, to those of unwilling minds. Thorough knowledge of the subject and definite information regarding regional and seasonal problems are essential. A balanced field program is desirable, and to accomplish this, careful planning of the program to cover all phases of the beekeeping industry must be made. Commercial beekeepers, farmer beekeepers, orchard beekeepers and beginners have many problems in common, and yet there are fine points in management which differ much in each phase and which require careful attention to the facilities of the beekeeper.

Beekeeping surveys sometimes required.—In some cases it is necessary to make a beekeeping survey in order to become acquainted with the problems before the program can be planned. It is not enough to travel about the state at the beck and call of county agents, individual beekeepers or beekeepers' associations. Nor is it enough to conduct certain seasonal management demonstrations or speak to gatherings of beekeepers, with no regard for a long-time beekeeping program.

Publicity and correspondence effective.—To make work in the field effective, as well as to do the routine office work, such as caring for correspondence and reports, it is necessary to spend some time in the office. It is entirely possible to spend too much time in the field and not enough time in the office. Travel is expensive and the number of persons who receive instruction on a given trip is often disappointing. With limited funds available for extension work and the entirely reasonable demands from taxpayers to reduce the tax burden, it is in line with good management to give serious thought to means which may be used to reach larger numbers of beekeepers without adding to the financial outlay. Radio talks, news articles, monthly news letters, circulars and bulletins are means to this end. The monthly news letter rates especially high in this respect. Thousands of them distributed under frank through the county agents' offices each month will reach more beekeepers in the minimum of time than any other means. The material in the news letter is seasonal and is intended only to supplement circulars and bulletins which cover the subjects in more detail. The news letter should be confined to one

page as nearly as possible. The average beekeeper is not a reader and will be interested only in statements which are short and to the point.

Another means of instruction by mail that is of high order is the correspondence course in beekeeping. A set of about 10 lessons and as many practical exercises made up of questions on practical beekeeping problems and enough of the simpler technical problems to add interest, if taken seriously by the student, will start him on the right road in beekeeping. Many good beekeepers have been found whose only instructions were in the beekeeping correspondence course. Two important factors enter into the correspondence course training. The student must study beekeeping literature and he must be led to apply the knowledge gained to his beekeeping practice.

Radio talks require time and particular attention to the accuracy of statements. It takes time to prepare a good radio talk, but the specialist who will take the necessary time to put interest as well as facts into his manuscript will find it an important part of his program.

Cooperation and affiliations.—To plan and execute a balanced program of work, close cooperation must be established with all agencies and persons who may influence the operations of the program. Opportunity for cooperation varies according to the extension organization within the state. In some states the extension specialist is a member of the subject matter department where the professor in teaching and research has a supervisory capacity over the nature of the field instructions and, to some extent, over the activities of the specialist. At the same time the field schedule is handled in the division of extension. In this case, the planning is necessarily a matter of cooperation between the professor, some person in the extension division and the specialist. This is a highly satisfactory arrangement.

Where the specialist is located in an extension department which is isolated from the subject matter department, cooperation with others may be difficult. This arrangement leaves the specialist alone to plan his work. Advice and assistance in planning and the acquisition of new knowledge from a subject matter department is mainly lacking in this case.

Extension and Regulation, Separate Fields.—Some workers in the beekeeping field find themselves facing the beekeeping public in a dual role. While the work of the apiary inspector necessarily has a certain educational value, on the other hand, it should not be necessary for the extension specialist to serve as apiary inspector. While there should be the most hearty cooperation between the inspection and the extension staffs, yet it is desirable that each part of the work be in a separate department and that the work be done by different individuals. Regulatory work does not always lead to amiable relations and attitudes, and in order that the specialist may have the most friendly relations with everyone, and the greatest degree of freedom in his work, he should not be vested with regulatory powers. Anyway, there should be plenty of work in any state for two efficient persons, in two separate positions.

Cooperation with Civic, Agricultural Groups Essential.—Some outside factors which influence the extension activities and which are

considered in making the program of field work are the county agents, 4-H club agents, individual beekeepers and fruit growers, and various organizations like beekeepers' associations, horticultural societies, service clubs and schools. Fullest cooperation with these individuals and organizations is necessary and without which a balanced program cannot be planned and executed. In some cases it may be wise for the extension specialist to become definitely affiliated with the educational activities of an organization. It is not desirable, however, to establish affiliations which may have political or definite commercial aspects, and usually it is not desirable for the specialist to hold office in these organizations. It must be kept in mind that the aim of extension work is purely educational and dangers of political and commercial entanglements should be carefully avoided.

Relations with Inspection Workers.—Full cooperation must be maintained with the apiary inspection staff, although it is desirable that the two activities be kept in entirely separate departments. In some cases effective work may be done by the extenson specialist and the apiary inspector in cooperation in an American foulbrood eradication program. In this effort the specialist first covers the area by conducting a series of educational meetings for the beekeepers in which the diagnosis and treatment of the disease is stressed. This may require two or three years. In some New York counties this work has resulted in the organization of the beekeepers in an American foulbrood eradication campaign under the direction of the state apiary inspector, with splendid results. In these counties the beekeepers have been able to secure an appropriation of $500 to $1000 from the county board of supervisors to start the work, after which the Department of Agriculture and Markets adds sufficient funds to carry out the work. In one county in 1935 the effectiveness of such cooperation was made manifest by the county appropriating $500 toward inspection work, while the state used over $1500 additional funds. The effect upon the extension work in this county was almost magical. Where in former years the attendance at local demonstrations and county meetings had been nominal, in October the annual meeting swelled from the usual handful of beekeepers to more than 150, because of the enthusiasm generated through the eradication campaign. This is only one of many instances of helpful cooperation between the two departments.

Beekeeping regions.—Regional problems are influenced by climatic and soil conditions which determine the nature of the flora and the time of the honey flows. Since beekeeping practices must be adapted to the timing of the honey flows, it is possible to plan and execute a balanced program only by considering each region separately.

In states having only one honey flow, regional differences are practically nonexistent except where latitude or altitude may influence the time of the honey flows. The problem is different where soil types or climatic influences divide the state into two or more characteristic regions. Typical examples of sharp contrasts in beekeeping regions within a state are found in New York. A short discussion of the regional problems of this state willl illustrate the necessity for the extension program to provide regional instructions in beekeeping.

THE CLOVER REGION.—A glance at the soil map of New York state is all that is necessary to determine the region where the clovers grow best, in the north central and St. Lawrence river areas. This is the clover honey region. Here the sweet soil and climate are favorable to clover. Because the clover blooms early in the summer it is necessary for the beekeepers of this region to manage the bees so that the colonies will be strong early in the season. Good fall and spring management is especially necessary here. An abundance of young bees for the winter cluster, abundance of good winter stores, abundance of insulation and abundance of room for brood rearing are essential factors. When the honey flow arrives, swarm control and proper supering are seasonal problems which have a decided bearing on the size of the honey crop.

THE BUCKWHEAT REGION.—In the southern part of the state, occupied by the Allegheny plateau and the Catskill mountains, except for a few narrow valleys, the honey flows arrive in late summer and early fall. Buckwheat, goldenrod and other late-blooming flowers supply most of the nectar. In general, this area is known as the buckwheat region. Although good wintering of bees is necessary, it is not so necessary that the colonies be strong early in the spring. In this region it is possible to divide strong colonies in May and build them up in time for the honey flow. The swarming problem is not so acute in the buckwheat as in the clover region. Considerable honey is stored in the brood nest, which simplifies the preparation of bees for winter.

LONG ISLAND.—Conditions on Long Island present some interesting problems in beekeeping management not found in any other part of New York state. Long Island is essentially a coastal plain area. The climate is mild, moist and windy. The nectar-bearing plants are legion and some kinds of plants or trees are in bloom from April to November. Since Long Island is a land of large estates, summer homes and commuters from New York City, many plants, shrubs and trees have been introduced from all parts of the world. The native flora is typical of the Atlantic coastal plain. At no time is an intense flow of nectar to be expected, but all through the spring, summer and fall some nectar and pollen are collected by the bees, with an occasional short surplus honey flow. This condition prolongs brood rearing and greatly complicates all phases of beekeeping management. Thousands of colonies exist on the Island, owned not by honey producers but by fanciers. It is obvious that it is necessary to provide a special program of beekeeping for Long Island.

In addition to the differences in apiary management made necessary by climate and soils, beekeeping practice must be adapted to the purpose for which the bees are kept.

Beekeeping for orchard pollination.—Since honeybees have a greater economic value for pollination than for honey production, it is appropriate to mention three areas within the State of New York, which, if it were possible to concentrate them into one area, would properly constitute a separate beekeeping region. The Hudson valley, a narrow strip along the western shore of Lake Champlain, and a wider area along the southern shores of Lakes Ontario and Erie comprise the principal fruit-growing sections of the state. Thousands of colonies are rented by the fruit grow-

ers of these areas, while other thousands of colonies are owned by the fruit growers and maintained in the orchards.

A special program of work has been developed for beekeeping in the fruit-growing areas. The necessity for extra strong colonies in May for use in the orchards and for no other commercial use during the season, the difficulty of producing strong colonies to be moved into the orchards to work on the blossoms and out to the honey-producing areas after the blossoming periods, problems of losses incident to moving and by poisoning, the spreading of American foulbrood due to transportation and many other problems due to the peculiarities of this kind of beekeeping, are encountered. It is evident that orchard beekeeping presents the most difficult problems in the entire beekeeping program. Economically it is one of the most important parts of the program. In some states fruit growing is a major agricultural industry, many persons deriving part or all of their incomes from this source. The consumer public is interested in the success of the fruit-growing industry because fruits of many kinds constitute a large part of the human diet. Not only do the fruit-growing areas constitute a beekeeping region, but a phase of beekeeping also, which is rapidly growing in interest and in demands for attention.

Beekeeping on the farm.—Not many years ago small apiaries were found on many farms widely distributed all over this country. Most of these bees were in a constant state of neglect, while the farmers had no reason for keeping bees except that they liked to have a few bees around or they supplied a meager quantity of sweets for the table. The very nature of this kind of beekeeping resulted in its destruction, through the ravages of bee diseases and changing honey flow conditions. It seldom was profitable and in many sections constituted a menace to commercial beekeeping. The condition still maintains in a lesser degree in some sections of the country. No one desires the return of this kind of beekeeping, but a healthy development of this phase of beekeeping along the right lines of colony management in those areas where commercial beekeeping is impossible is desirable, and in fact, is of considerable economic importance. Because of the limited time which can be devoted to the bees, the farmer should keep only a few colonies, which if they are rightly managed should supply his table with honey and a small supply to be sold to a local trade. Thus bees rightly managed on the farm may become an additional source of cash income.

The small honey crop from farm apiaries is not the most important reason why a wide distribution of bees on the farms of this country is desirable. Farm crops are grown to sustain human and other forms of life and without cross-pollination some of these crops cannot be grown. It is well known that honeybees perform an important part in this necessary service and it will do no harm to point out a few examples.

Not long ago a grower of cabbage seed told the writer that for a number of years he failed to secure a profitable crop. Learning something about the value of bees in cross-pollination, he secured a few colonies for the purpose. He stated that the bees now work heavily on the cabbage blossoms and that the set of seed since installing the bees has been highly satisfactory. The use of bees for cross-pollination of certain green-

house crops all over this country is too well known to require discussion. These same crops, cucumbers, melons, etc., must have the services of insects when grown outdoors. Most important among the plants upon which human life depends are the legumes, most of which must have or at least are greatly aided in seed production by cross-pollination. It seems to be a fact that not only are wild insects insufficient in numbers properly to perform this important function, but that many of them are not as efficient as honeybees.

It has been observed that the annual buckwheat seed crop in New York state is correlated very closely with the buckwheat honey crop. When conditions are such that the bees work well on the buckwheat blossoms, the farmers harvest a good crop of buckwheat seed also. Both the buckwheat seed and the buckwheat honey crops were notoriously short in 1935. Weather conditions prevented the bees from flying much of the time during the buckwheat blossoming period.

At present beekeeping is at a low ebb on the farms in the buckwheat region and farmers frequently report that since the bees have disappeared, the buckwheat crop is no longer satisfactory. While buckwheat is not an important farm crop in the United States as a whole, yet in the buckwheat region it is important. The value of the buckwheat crop annually in the State of New York is approximately one and a half million dollars, while the buckwheat honey crop amounts to over one million pounds annually.

It is significant that E. F. Phillips found on an extended trip through Russia that the Soviet government is keeping large numbers of colonies of bees on the collective farms and is increasing these apiaries solely for farm-crop pollination. He also reports that the German government has the same idea, for which considerable sums of money are appropriated to the beekeepers' associations to encourage beekeeping.

It is unnecessary to continue the discussion further along this line. There is no doubt that the beekeeping extension program must include the farmer beekeeper. Simplified methods of management which are easily followed and which require a minimum amount of time and labor, yet which will keep the bees in a prosperous condition, are necessary for this kind of beekeeping.

Commercial beekeeping.—The commercial beekeeper is interested in one objective mainly, that of producing the maximum honey crop and selling it at the maximum price. Usually he devotes his entire time to beekeeping, and because he seldom keeps records he has no means of knowing whether he is adequately paid for his work. Because of the prevailing low prices for honey it is essential that the commercial honey producer adopt methods of the greatest efficiency in all departments of his work if he hopes to continue in business. This applies equally to apiary management, equipment and management in the honey house, preparation of the honey for market, honey packages, methods of marketing and the efficiency of hired help. As long as a vast majority of the commercial honey producers of this country fail in one or more of these factors, there will be plenty of work for the extension specialist, even though there were no other phases of beekeeping.

Junior or 4-H beekeeping.—Workers in the field of beekeeping generally concede that there is room and opportunity for vast improvement in the personnel of beekeeping. Progress is greatly impeded by the static condition of the beekeeping industry. This is especially true of commercial beekeeping. It seems that hopes for improvement lie mostly in opportunities in training young beekeepers. In many states the 4-H club and Junior or Young Farmer movements include beekeeping as one of the projects. This is hopeful to the beekeeping industry, although it is not so recognized by many commercial beekeepers who openly or passively oppose the work. It is encouraging, however, to note that in many quarters this opposition has broken down and even moral and financial backing is given by adult beekeepers to the movement. The Junior project is deserving of the best efforts on the part of the extension specialist and it should be included in the beekeeping program of every state.

Honey marketing.—Probably the most effective influence which the extension specialist can use in advancing the use of honey is to talk about the wonders of honeybee life to service clubs, women's clubs and school assemblies. If the address is made interesting, the audience is left with a desire to eat honey without the speaker appearing to be advertising the product. Numerous engagements of this nature may well occupy a prominent place in the extension program. In cooperation with state and local beekeepers' associations, attention should be given to the educational value of honey exhibits at fairs and other places where large numbers of people receive information about honey and the privilege of tasting it and purchasing a package to be taken home. Other means of aiding in honey selling might be mentioned. The specialist should take advantage of every opportunity to assist in educating the public to the use of honey.

Demonstration apiaries.—Among the complex activities of the extension specialist, no doubt the demonstration apiary affords the most effective means of extension teaching in beekeeping as well as in honey marketing. The demonstration apiary is a seasonal meeting place for the beekeepers of a locality, where they may spend several hours assisting in the manipulation of the colonies and discussing beekeeping and honey-marketing problems. The specialist has the opportunity to answer questions and to give personal attention to the problems of each beekeeper in a way that is not possible in any other type of beekeepers' meeting. The beekeepers see the practical demonstration of seasonal management methods and are able to go home and apply these methods to their own bees. Interest may be added to the demonstration meetings by contests like queen hunting and queen clipping, queen introducing and smoker contests. In the autumn meetings the matter of the preparation of honey for market and actual honey marketing problems are discussed and demonstrated.

It is desirable to hold at least three method demonstrations in each demonstration apiary during the year—spring, summer and fall. The spring meetings held in New York state in May are devoted to unpacking the colonies and making the regular spring examinations. Some of the

practical demonstrations at this time are: uniting weak colonies, dividing strong colonies for increase, uniting package bees with weak colonies, installing package bees to start new colonies, requeening, adding room to extra-strong colonies, and the preparation of colonies for moving into the orchards for pollination purposes. The midsummer demonstrations are held from late June to early August and cover such problems as swarm control, proper supering during the honey flow, requeening and American foulbrood control. The autumn meetings, from the middle of September to early November, are devoted to the preparation and insulation of bees for winter and to honey-grading and honey-marketing problems.

In New York state, demonstration apiaries exist in all of the beekeeping regions and cover every phase of beekeeping. Only part of the colonies in an apiary are taken for demonstration purposes, and the rest are left as check colonies. The trouble is that after two or three years no check colonies remain, since the beekeeper usually decides that it is better to operate all of the colonies after the methods used in the demonstrations. Usually when the apiary has been used for demonstrations for two to four years, another apiary in another section of the county is selected and the demonstrations are moved to that locality. This distributes the work so as to reach as many localities as possible and yet to stay in one place long enough to do effective work. The scheduling of the demonstration part of the beekeeping program is all done in cooperation with the county agricultural agent or the 4-H club agent. There are now more than 50 such demonstration apiaries in New York state, in 26 counties, located in all of the different climatic and honey-flow conditions that are found. Data gained from the demonstration colonies in the past five years show that nearly 50 per cent more honey has been produced annually by the demonstration colonies than by the check colonies.

Since the success of beekeeping in the future depends on a properly trained personnel, it is important for the extension specialist to have the right background and training. It is important that the beekeeping industry develop in a healthy and normal manner which cannot occur without proper instruction in all of the beekeeping problems as related to regional differences and phases of beekeeping. Out of the knowledge arising from proper instruction should develop a well-planned and balanced program of work.—1-4-36.

THE WISCONSIN OCCUPATIONAL BEE TAX

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In these days of trying to balance the budget, those of us who are responsible for carrying on bee-disease control in our respective states are eager to find some way to secure more funds for the work. The Wisconsin legislature of 1933, finding it necessary to reduce its expenditures to meet its income, recommended charging, if at all feasible, a license whenever a service was rendered to a group by the state.

Beekeepers want inspections.—A special committee investigating the activities of the Department of Agriculture and Markets with the idea

of cutting out any service that to them did not seem absolutely necessary, called in the beekeepers for such a hearing. As a result of this hearing they found that the beekeepers were apparently unanimous in their opinion that the bee-inspection service was not only worth while, but of absolute necessity for the protection of their industry and that the beekeepers themselves were willing, if necessary, to help pay the cost of the work providing all other groups receiving such service did likewise. The finance committee requested that the department make a careful study of taxes and license fees of other states and of the provinces of Canada and submit them together with some recommendations for their consideration. At a hearing before this committee the department pointed out that if any licenses were going to be charged on the basis of those deriving benefit therefrom, the fruit growers, clover and alfalfa seed growers and others would have to be included.

The difficulty of collecting such fees, experienced by other states, as well as our own in collecting similar fees, was also pointed out to this committee, and the fact that if such fees were to be collected in justice to those who did pay, the collection cost would exceed the receipts. The budget director finally decided that if the department was going to have difficulty in collecting these small fees and it would not be practical to tax those benefiting from this service other than the beekeepers, that an occupational tax might be the solution, leaving its collection to the local authorities. Consequently, under that law there was imposed on every person, firm or corporation owing two or more hives of bees or any used and unsterilized or undisinfected bee equipment, an annual occupational tax of 25 cents for the first hive and 10 cents for each hive in excess of one. Bees and bee equipment on which such taxes were paid were then exempted from all property tax. Prior to this statute there was on the books an exemption "not exceeding five colonies (swarms) of honeybees, kept for the use of the owner and his family." This tax was to be collected in the same manner as taxes on personal property, allowing the municipality to deduct "reasonable costs" incurred in its collection and the balance of 20 per cent was to go to the town, city or village in which the bees were kept and the balance went to the state treasury. No provision was made to use any of this fund for bee inspection, it presumably being merely intended to offset the $6200 appropriated to the department for apiary inspection.

Indefinite terms in the law.—There being no definition of terms included in the statute, the assessors were at a loss to interpret what constituted a hive and how they were going to determine when equipment was "unsterilized and undisinfected." Upon request, the department helped relieve this situation somewhat by working out some terms and helping the assessors agree upon the definitions until the law could be changed. In these definitions it was decided what was to make up a hive, and unless equipment had been definitely branded by the inspector as having American foulbrood, and there was no question about its being cleaned up, it was decided that such equipment would have to be simply ignored so far as the tax was concerned.

The idea of including the terms "unsterilized and undisinfected" had

merit in that it would discourage beekeepers from keeping equipment lying around year after year without cleaning it up, but to carry out the idea would to necessity require a system of branding marks and certification to serve as a guide to the assessors. This tax plan had another merit also in that it was intended to provide a complete registration of all beekeepers by county. Each town, city or village clerk was required to enter in a separate book the names and addresses of all the beekeepers with the number of hives kept by each and this list was to be furnished upon request to the state entomologist. Whether through misunderstanding or deliberate refusal to comply with the statute, practically no money was turned into the state treasurer's office last year.

Nonenforcement penalty added.—The 1935 legislature was prevailed upon to revise the statute in a number of ways, making the law a little more workable. In the first place the tax was placed only on colonies of bees themselves and not on any of the empty hives or equipment. The amount of the tax was left the same, namely, 25 cents for the first colony and 10 cents for each colony in excess of one. The bee equipment was also exempted from a property tax as were any bees that might have been covered with this tax. In the second place, 50 per cent of the tax was allowed to be retained by the taxation district in which the bees were kept and the balance was requested accounted for and paid into the state treasury in the same manner as state taxes on property are paid, the money so collected being returned to the state treasury with the provision that it should be used by the Department of Agriculture and Markets for the regulation and inspection of apiaries. In the third place, a penalty was placed on county officials for not carrying out their duty, as follows: "Any official charged with a duty under this section who shall fail to perform that duty shall be guilty of a misdemeanor and shall be punished by a fine of not more than 100 dollars or by imprisonment in the county jail not to exceed 60 days or by both such fine and imprisonment."

While it is not anticipated that the receipts from this tax will amount to more than a few thousand dollars at the most, it gives the beekeepers rather definite assurance that their appropriation will be continued in that they are helping to pay for the service and it also gives the beekeepers a lever before the county board to secure county funds with the 50 per cent of the receipts that they receive. During 1935, 16 counties appropriated $2875, which was met on a dollar per dollar basis by the state funds. There has already been increased interest among some of the other counties, five new ones having already advised us that they have secured county funds to help in carrying on the work next year.

Cost of special inspections cut.—During the course of the revision of this law, we took advantage of the opportunity of changing one objectionable feature in our old law by the insertion of "the first of June" as being the time limit for applications for permits to move bees and used bee equipment without the possibility of being charged the cost of the inspector's traveling expense, unless it could be shown to the satisfaction of the state entomologist that it was impracticable to make application for such permit prior to that date. The statute provides that the

applicant may be charged the traveling expenses of the inspector and may be refused such permit until such expenses are paid. This has eliminated the rather common practice of certain beekeepers notifying us by telephone or letter that they wish to move bees and used bee equipment within the next day or two to outyards, new locations, fairs, etc., and would just have to move them without a permit unless such permit was issued immediately. Thus by notifying us a few weeks in advance, a considerable saving can be made in the cost of these special inspections. At the present time we have 52 local inspectors scattered over the state who are assigned to local inspections, and the cost of issuing 500 permits annually is kept under $3000. Heretofore special inspections were made time and time again costing $25 to $30 each when the material to be inspected might consist of only a single colony of bees or a small amount of equipment, which, of course, was worth but a small fraction of the cost of the inspection.—9-6-36.

VALUE OF FOODS OTHER THAN POLLEN IN NUTRITION OF THE HONEYBEE[1]

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In an article published previously (*3*), the writer has given a review of the literature on the value of pollen substitutes. Results of the experiment described in that article were as follows: Young bees can develop their bodies to an approximately normal extent when fed dried yeast, fresh whole milk, skim-milk powder, whole egg, egg yolk, and egg white, instead of pollen. Colonies composed of such bees can rear their brood, but the number of bees produced is variable, the greatest being produced by the dried-yeast-fed colony and the lowest produced by that fed egg white. Emerging bees reared by the experimental colonies were in general normally developed. Rye-flour food did not produce a satisfactory development of the bee body, nor did the colony composed of such bees rear brood. The greatest mortality was observed in the colony fed rye-flour food (52 per cent), the lowest in that fed dried yeast (15.47 per cent).

In the present paper an experiment is described[2] in which the value of a wide range of foods for bees was investigated.

To discover the suitability of various foods for bees, the following data were secured:

(1) The changes in the weight and the nitrogen content of the thoraces of experimental bees. (It was found (*4*, *6*) that in both respects there is an increase with the age of bees, provided the latter have adequate food.)

(2) The mortality of the experimental bees.

(3) The brood-rearing activity of the experimental bees.

[1] Paper 1408 of the Scientific Journal series of the Minnesota Agricultural Experiment Station.

[2] Grateful acknowledgment is made to Dr. M. C. Tanquary and Dr. Wm. A. Riley for their interest in the work and helpful suggestions during the preparation of the manuscript. Thanks are due to Swift and Company of South St. Paul, for supplying some of the foods for the experiment.

(4) The weight and nitrogen content of the emerging bees reared by the colonies fed with the experimental foods.

(5) The quantity of the reared brood.

(6) The building activity of the experimental bees.

Methods.—Since the procedure in the present experiment was somewhat different from that published previously (*3*), it will be described fully now.

Young bees were allowed to emerge during 6 and 10-hour periods in a constant-temperature chamber adjusted to 33° C and 75 per cent humidity. During three consecutive days they were brushed in a small

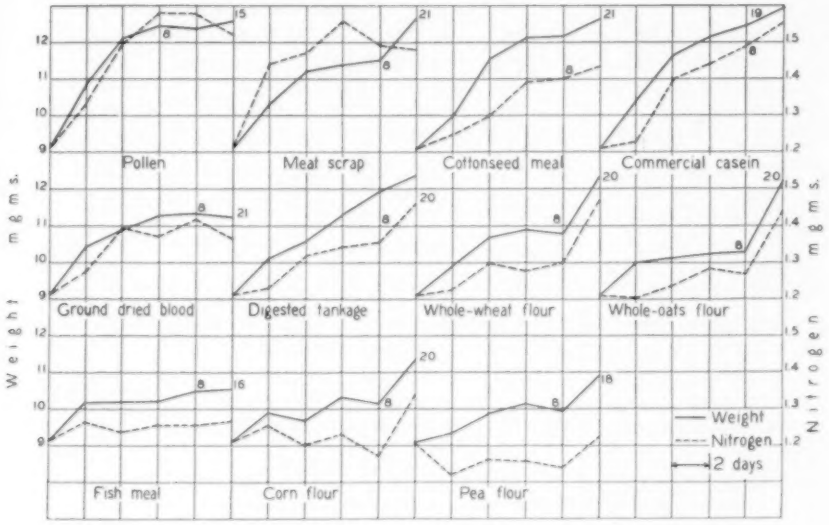

Fig. 1.—Changes in dry weight and nitrogen content of thoraces of experimental bees. Numbers on the growth curves signify the age of bees (in days) taken for determination of weight and nitrogen content.

three-frame nucleus, provided with a freshly drawn comb filled with sugar solution and the experimental food. Such a nucleus was located in a screen cage, dimensions 50 by 40 by 15 inches. The cages were kept in the extraction room in the basement of the administration building of the university. On the third day a fertile queen was added to the colony. On the fourth day the sugar solution and water were offered to the bees. On the fifth day a frame of foundation was hung alongside the comb already present in the nucleus. This was done to study the building activity of the experimental bees. On the seventh day the young bees which emerged during a one-hour period were marked and brushed into the nucleus. Changes in the dry weight and the nitrogen content of the thoraces of these bees were determined every two days, in the manner already described (*3*). The thoraces of 20 bees were used for each sample. Starting from the seventh day, the brood-rearing activity of the colony

was observed. Ten days after the first sealed cell was noted, the combs with brood were photographed, the number of sealed cells and of larvae just about to be sealed was counted, and the combs were placed in a constant-temperature chamber. The dry weight and the nitrogen content of the emerging bees were determined as previously indicated (3). The colonies which did not rear brood or reared their brood inefficiently were kept in the experiment a longer time but those which did rear brood

Table 1.—Composite table of results.

	Pollen	Meat Scrap	Cotton-seed Meal	Com-mercial Casein	Ground Dried Blood	Di-gested Tank-age	Whole-wheat Flour	Whole-oats Flour	Fish Meal	Corn Flour	Pea Flour
					No. Bees per Colony						
	5438	5015	6291	4752	4399	4661	3914	4687	3779	5957	4056
					Average Dry Weight of Thoraces, Milligrams						
8 Days	12.3	11.5	12.1	12.4	11.3	11.9	10.8	10.3	10.5	10.1	9.9
Old Bees	12.5	12.6	12.6	12.8	11.2	12.4	12.3	12.2	10.6	11.4	10.9
					Weight Increase Over Emerging Bees, Per Cent						
8 Days	37.3	27.5	33	36.3	24.2	30.8	18.7	13.2	15.4	11	8.8
Old Bees	37.4	37.4	37.4	40.7	23.1	36.3	35.2	34.1	16.5	25.3	20.
					Average Nitrogen Content per Thorax, Milligrams						
8 Days	1.57	1.49	1.4	1.49	1.41	1.36	1.3	1.27	1.26	1.17	1.14
Old Bees	1.52	1.48	1.43	1.55	1.37	1.46	1.47	1.44	1.27	1.34	1.22
					Nitrogen Increase Over Emerging Bees, Per Cent						
8 Days	24.8	23.1	15.7	23.1	16.5	12.4	7.4	5	4.1	−3.3	−5.8
Old Bees	25.6	22.3	18.2	28.1	13.2	20.7	21.5	19	5	10.7	.8
					Percentage Mortality						
	12.7	18.7	27.8	49.7	45.3	43.9	43.6	42	96.6	44	92.9
					Behavior						
	Quiet	Quiet	Quiet	Quiet	Restless	Quiet	Quiet	Quiet	Very Unquiet	Very Unquiet	Very Unquiet
					Food Consumption						
	Good	Good	Good	Good	Satis-factory	Satis-factory	Good	Good	Very poor	Very good	Very poor
					Brood-rearing Activity						
	Pro-duced Young Bees	Pro-duced Young Bees	Pro-duced Young Bees	1 Day to Sealed Larvae	1–1½ day-old Larvae	1–2½ day-old Larvae	1–2 day-old Larvae	1–3½ day-old Larvae	None	None	None
					No. Sealed Cells and Larvae Before Sealing						
1889	170	191	0	0	0	0	0	0	0	0	
					Day Started to Draw Foundation						
Next	Next	Next	Next	Next	Next	Next	Next	2nd	4th	2nd	8th

were discarded after their brood combs were removed to the constant-temperature chamber.

Dead bees were not counted during the first six days of the experiment. Afterwards a daily count of dead bees was continued for a period of 21 days. The count was not continued longer because the control colony was discarded after that period. The percentage of dead bees was established in the way previously described.

Foods.—Meat scrap, ground dried blood, digested tankage, fish meal, whole-wheat flour, whole-oats flour, corn flour, pea flour, cottonseed meal, and commercial casein were used as pollen substitutes. These foods were mixed with honey in a ratio 1:4 by weight, except pea flour and cottonseed-meal foods which were mixed in a ratio 1:5. One part of commercial casein was used to seven parts of honey by weight.

The mixed foods were distributed to the cells of virgin combs by means of a spatula. The bees were given such foods *ad libitum*.

A colony made in the same manner as the experimental colonies and provided with a comb containing pollen and honey served as a control.

Results and discussion.—The results of the experiment are presented in fig. 1 and tables 1 and 2.

Examination of the chart shows that the bees from the colonies fed pollen, meat scrap and commercial casein developed their bodies at practically the same rate. The dry matter of bees from the cottonseed-meal-fed colony increased similarly to that of the bees from the previously mentioned colonies. However, the nitrogen increase was slower. The bees from the rest of the experimental colonies showed poorer development during the first eight days of their lives. This is especially true of the bees from the colonies fed fish-meal, corn-flour and pea-flour foods. In the two latter colonies the nitrogen content of the thoraces of the experimental bees even diminished. Nevertheless, when we examine the weights and the nitrogen content of the thoraces of the old bees (15 to 21 days) we find, table 1, that in all cases (except the ground dried-blood-fed colony) they increased. This fact suggests either that the digestibility of food given to those colonies was lower so that larger amounts of nutrients had to pass through the digestive tracts of the bees to produce an effect similar to that given by the more adequate foods, or that the amount of necessary constituents per volume intake was smaller than that which is required for a normal development, as it might have been in the case of the grain foods. Large amounts of starch present in the latter foods filled the digestive tracts of the experimental bees with an indigestible material (7). However, it is not improbable that both factors played their role in every case.

Table 2.—Dry weight and nitrogen content of energing bees.

Food	Dry Weight, mgms.				Nitrogen per Bee, mgms.			
	Head	Thorax	Abd.	Whole	Head	Thorax	Abd.	Whole
Normal in confinement	2.5	8.9	6.5	17.9	.26	1.05	.52	1.83
Meat scrap	2.3	8.2	7	17.5	.27	.98	.67	1.92
Cottonseed meal	2.4	8.5	5.5	16.4	.23	.95	.52	1.7

The lowest mortality was in the colonies which produced young bees. Colonies fed those foods which caused a slower development showed a higher mortality than those fed more efficient foods (except the colony to which the commercial casein diet was given). This higher mortality was especially evident in the fish-meal and pea-flour-fed colonies. Bees in these colonies showed also the greatest unquietness, and their food consumption was very poor. The fish-meal mixture seemed to be even repellent to bees. The food consumption in the corn-flour-fed colony was very good, but the colony was very restless, bees sometimes even deserting the hive.

Brood-rearing activity of the experimental bees varied widely. In the control colony it did not differ from that of the normal outside colonies.

The bees on the meat scrap diet started brood rearing normally. However, the larval food was rather thin and transparent, while normally it is thick and milky in appearance. The larvae were sealed on the sixth day after hatching. Nevertheless, the sealed brood did not form a compact

mass but was rather scattered because the bees removed some larvae from the cells before they reached maturity. From 141 sealed cells only 123 young bees emerged. Eighteen cells (13 per cent) remained unopened. Twelve dead larvae and six dead pupae were found in them. Their death apparently was not due to the external causes.

The cottonseed-meal-fed colony started brood rearing normally. Nevertheless, after the larvae had acquired the appearance of those three and a half days old, they were removed by the bees. The larvae looked healthy and were provided with an abundance of food which was of normal consistency and color. Such brood-rearing activity continued for 18 days. Then, in order to stimulate a normal brood rearing, the queen was removed from the colony. On the fourth day after that, the first sealed cell was noted. Afterwards the brood rearing continued normally. However, the sealed cells did not form a solid mass, but were rather scattered because some larvae were removed by the bees. All the sealed brood emerged.

The bees on the commercial casein diet started their brood rearing normally, but the larvae were afterwards removed by the bees. Those larvae which reached the stadium before sealing were unhealthy in appearance. There was an abundance of larval food in the cells with larvae, which was of a normal color and consistency. Some of the older larvae were sealed but they died in the cells either in the stadium of prepupae, just starting to pupate, or in the earliest pupal stage. When the queen was removed, the queen larvae, which the bees started to rear, were supplied with an enormous amount of food. Nevertheless, they looked unhealthy and died. Currie (*2*), working on pollen substitutes in Australia, found that "on casein alone the young bees reached the pupal stage but failed to emerge adults," although as he stated previously (*1*), "casein alone can lead to development of pharyngeal glands."

This finding suggests that in the study of bee nutrition it is necessary, as was pointed out by the writer previously (*3*), to follow more than one factor. The development of the pharyngeal glands alone cannot serve as an indication of the suitability of any food as a pollen substitute since such developed glands may secrete a product that is deficient in a factor or factors which are essential for a normal development of growing individuals.

The colonies fed ground dried blood, digested tankage, whole-wheat flour and whole-oats flour started brood rearing, but in every case the larvae were removed from the cells after they reached the age of one and a half to three and a half days in appearance. Removal of the queen did not stimulate the brood rearing as it did in the cottonseed-meal colony. The larval food was waterish, not milky in appearance, and little of it was present in the cells with larvae. Even the queen cells were supplied with a little food. Such brood-rearing activity continued only for seven days in the ground dried-blood-fed colony. The digested-tankage colony reared brood for 17 days. That fed whole-wheat-flour food continued nursing activity for 16 days and only the whole-oats-fed colony reared brood for 21 days—up to the time of discarding. There was no brood rearing in the colonies fed fish meal, pea flour or corn flour. The eggs

apparently were removed or eaten by the bees as soon as the queen laid them, since not even hatched larvae were observed in those colonies.

More experiments are necessary to find the exact cause of the inability of bees to rear larvae when certain foods are offered to them. The composition of foods, however, may suggest the possibile causes of this phenomenon. It is obvious from table 3 that those foods in which all the elements essential for the development of young animals were well represented were able to cause a normal development of emerged bees, and to enable the bees to rear brood. On the contrary, foods which contained a large percentage of indigestible material and the mineral content of which was lower did not produce a normal development and brood rearing. The apparent discrepancy in the case of ground dried blood, digested tankage,

Table 3.—Percentage composition of foods.*

	Pollen	Larval Food	Meat Scrap	Cotton-seed Meal	Whole-oats Flour	Whole-wheat Flour	Corn Flour	Ground Dried Blood	Di-gested Tank-age	Pea Flour	Fish Meal
Water	7.66	24.15	5.	7.8	7.3	11.3	12.5	9.7	7.9	9.5	10.5
Protein	16.6	30.62	50.	39.8	16.1	13.3	9.2	82.3	60.4	24.6	51.4
Fats	10.63	15.22	10.	8.3	7.2	2.2	1.9	.9	7.4	1.	8.3
Carbohy-drates	16.24	14.05	6.2	27.4	67.5	71.4	75.4	3.8	3.7	62.	
Ash	3.3	2.34	36.	6.6	1.9	1.8	1.	3.3	15.3	2.9	28.1
Ca	.02		.029	.265	.069	.31	.018	.04		.084	.109
Mg	.14		.059	.462	.11	.09	.084	.02		.149	.133
K	.96		.847	1.39	.344	.274	.213	.375		.903	1.671
Na	.09		.21	.234	.062	.037	.039	1.305		.104	.373
P	.43	.67	.507	1.193	.392	.238	.19	.155		.4	1.148
Cl	.03		.189	.037	.069	.07	.146	1.4		.035	.528
S	.2	.38	.513	.485	.202	.18	.111	.685		.219	1.119
Cystine	.51	3.28	1.55	.9	2.	2.32†	1.03‡	2.	2.5	.57§	1.32
Histidine	2.41	1.74	1.76	7.2	3.5	3.35	.8	8.4	2.2	2.47	2.55
Lysine	.97	4.41	7.59	4.2	5.4	.92	0.	10.	2.5	5.4	7.45
Tryptophane			1.25		1.	1.14	0.			.15	1.25
Vitamins	B	AB	ABG	ABG	ABG	ABG	ABG	A	?	ABG	AB

* Data for this table were taken mainly from Sherman's "Food Products," 3rd ed., 1933; Sherman's "Chemistry of Food and Nutrition," 4th ed., 1933; Mitchel & Hamilton's "The Biochemistry of the Amino-acids," 1929; Henry & Mortison's "Feeds & Feeding," 19th ed., 1927. The sources of the data for the composition of pollen, larval food and bee body were given in the previous publication by the writer (*3*).

† Gliadin.

‡ Zein.

§ Vicelin.

and fish meal can be explained by an assumption that the availability of the food constituents might have been impaired by the processes used in the preparation of these foods in the factory. Moreover, the consumption of fish-meal food was negligible, the food being repellent to bees. There was very poor consumption of the pea-flour food. The high mortality of bees on this diet suggests that it was detrimental in spite of a very poor consumption.

When we exclude these foods we may see that the development of bees and their brood-rearing activity quite closely corresponds to the richness of the foods in the digestible food constituents, particularly proteins and minerals. Foods like rye or corn flour contain a small percentage of proteins. The main representatives of those proteins, gliadin of rye and zein of corn, lack one and two essential amino-acids respectively. Both rye flour and corn flour caused a very slight development of the body of the bees subjected to such a diet and the bees fed on these foods did not even attempt to rear brood. Proteins of the rest of the experimen-

tal foods contained all the essential amino-acids and in all cases the bees fed those foods attempted brood rearing. The body of the bee is rich in potassium and phosphorus. There are no data on the potassium content of larval food; nevertheless its phosphorus and sulfur content is quite high. If we follow the protein, potassium, phosphorus and sulfur content of the experimental foods and compare it with the brood-rearing activity of the bees fed these foods, we find that the latter quite closely corresponds with the former. This fact may be considered as suggestive, and it is being given further attention in our continued research. Consideration must be given also to the vitamin content of bee foods since vitamins play an important role in insect life.

The greatest number of bees was produced by the control colony. Table 2 shows that the nitrogen content of emerging bees from the colony in which nurse bees were fed meat-scrap mixture was the greatest and that the nitrogen content of emerging bees from the cottonseed-meal-fed colony was the lowest. This was due to the smaller amount of nitrogen present in the heads and the thoraces of the emerging bees produced by the latter colony. Although the thoraces of the emerging bees reared by the colony which was offered meat scrap for food contained less nitrogen than the thoraces of the emerging bees produced by the control colony, the total nitrogen content per emerging bee was greater in the meat-scrap-fed colony. This was due to the fact that abdomens of the bees produced by the latter colony contained 29 per cent more nitrogen than the abdomens of the bees reared by the control colony. This may serve as a further confirmation of the writer's findings (*3, 5*) that a protein-rich food tends to increase the nitrogen content of the abdomens of bees produced.

The building activity of the experimental bees was normal in all the colonies, except those fed fish-meal and pea-flour food.

Conclusions.—Bees can develop their bodies normally when fed meat scrap or commercial casein mixtures. Development on cottonseed meal, ground dried blood, digested tankage, whole-oats flour and whole-wheat flour proceeded more slowly. The development of the bee body on corn flour, fish meal and pea flour was very poor.

The lowest mortality was in colonies which produced young bees.

The behavior of colonies fed meat scrap, cottonseed meal, commercial casein, digested tankage, whole-wheat flour and whole-oats flour was normal. The ground dried-blood-fed colony showed restlessness, and the fish-meal, corn-flour and pea-flour colonies were very excited.

Only the control, meat-scrap, and cottonseed-meal-fed colonies produced young bees. Those fed with commercial casein, ground dried blood, digested tankage, whole-oats flour and whole-wheat flour unsuccessfully attempted brood rearing. The fish-meal, corn-flour and pea-flour-fed colonies did not even attempt to rear brood.

The young bees produced by the meat-scrap and cottonseed-meal-fed colonies were normal. But the emerging bees from the former colony contained the largest amount of nitrogen, which was due to the greater nitrogen content of the abdomens of those bees.

Building activity was normal in all colonies except those fed fish meal and pea flour.—9-2-36.

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PREPARATION, SHIPMENT AND INSTALLATION OF PACKAGE BEES

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Shipment of honeybees in combless packages has developed enormously during the past 20 years and today constitutes a volume of business of considerable importance. In 1934, 94 per cent of the shippers of package bees and queens in all portions of the United States reported the sale of 262,023 pounds of package bees, of which amount California shipped approximately 32,000 pounds. Since the gross weight of each package prepared for shipment is approximately two and one-third times the net weight of bees, the total gross weight of the shipping cages and bees for which express was paid would approximate 613,487 pounds.

Package bees are purchased primarily for three purposes: to assure the proper pollination of deciduous fruit trees, vegetables and seed crops requiring cross-pollination; to strengthen overwintered colonies; and to establish increase in the spring. Each package consists of two or more pounds of bees and queens. During recent years the number of package bees sold has been increased in the colder regions of the United States and Canada by the practice of killing colonies at the close of the honey flow and restocking the hives with package bees the following spring. These uses necessarily confine the shipment of package bees to a comparatively short period of the year—from March until the middle of June in California.

Methods of shipping package bees.—Package bees are shipped primarily by railway express, although a small number are transported by parcel post and by truck. The shipments of queens by air mail is increasing, and this mode of shipment may be extended to package bees in the future if suitable rates are obtained.

THE CALIFORNIA SHIPPING CAGE.—The bees are shipped in combless cages provided with a sugar syrup made by dissolving granulated sugar in an equal amount of water. When bees are to be confined to their cages for longer than average periods, the proportion of the sugar to the

water used should be increased to about two to one. For several years past the cage used by California shippers has been standardized and has given uniformly satisfactory results. It is 5½ inches wide, 7½ inches high, and 15½ inches long, inside dimensions. The two sides are screened, providing 231.5 square inches of surface for ventilation. A wooden block tacked in the bottom of the cage gives support for the No. 2½ sanitary can used to hold the syrup. The lid of this can has a seven-eighths-inch hole in the center to enable the bees to suck the syrup through a finely woven cloth that is fastened in place over the hole when the lid is hermetically crimped on the can. This type of can never leaks and does not clog, two considerations very important to the welfare of the bees. With this cage additional cluster supports are unnecessary. The device could be improved if narrow strips of wood were tacked to the top and bottom of each cage at the center. Such supports would increase the strength without adding materially to the cost. The top, bottom and ends of the cage are made of three-eighths-inch pine, insuring a light but strong cage. Although this is known as the 3-pound shipping cage, it is used to ship 2-pound packages and is sufficiently large to hold 4 pounds of bees and two queens during the cooler portions of the shipping season. When more than 4 pounds of bees are shipped, as where packages are destined for pollination purposes, a larger cage with greater ventilation should be provided.

Preparation of Packages for Shipment.—Package bees are produced in the northern half of the great valley in California, where climatic and floral conditions favor the stimulation of brood rearing in early spring. This early period of nectar production is followed by virtual dearth of nectar during the latter portion of May to the first or second week of July. Colonies are generally in two or three stories and at swarming strength by the first of April, when the active shipment of package bees begins. The bees that have wintered over have died, and the colonies are composed principally of young bees of the current season's production. Artificial feeding is rarely resorted to in this region except in the rearing of the cells from which queens are produced for the packages.

Queens included with package bees are generally confined in a small queen cage with or without food or attendants. Until a few years ago all queens were shipped in cages with attendants and food, but recently an increasing number of queens have been shipped alone in foodless cages under the supposition that they thus receive better care from the package bees and arrive in better condition. This method of shipment will be used to a greater extent in California during the next shipping season.

In filling the cages the majority of California shippers shake a quantity of bees from different colonies through a queen excluder into a well-ventilated "shaker box" to exclude the drones, and then transfer the bees to the shipping cages, allowing sufficient overweight to make up for the amount of honey carried by the bees and the small percentage of bees that die naturally in transit. This method insures a better distribution of bees of all ages and more normal packages than where the bees are shaken directly from the hive into the shipping cage. When sufficient

bees have been shaken into a cage, the small cage containing the queen is fastened near the top center of the shipping cage by means of a flexible wire or metal strip. A narrow kerf about 1 inch long extending from the center hole in the shipping cage aids in keeping the queen cage away from the feeder can when it is put in place.

The queens are generally caged the same day the packages are shipped and are seldom held for more than 24 hours. In the experimental apiary of the University of California queens are confined without attendants in foodless two-holed Pinard queen cages and are placed near the entrance of each nucleus with a handful of bees until the required number are

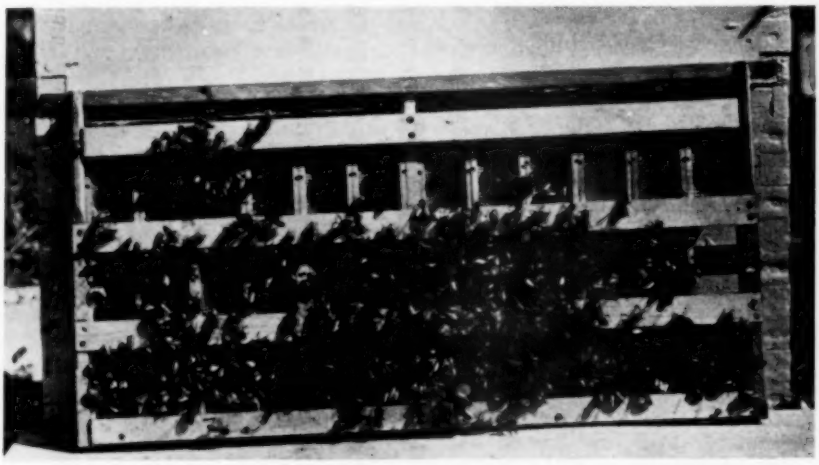

Fig. 1.—Special frame holding 36 foodless queen cages as used by the writer in the University of California apiary, at Davis. The cages covered with bees contain queens.

caught. Queens are never exposed to the sun. The cages are then collected, placed in a special frame holding 36 cages, fig. 1, and given to a queenless colony or placed above a queen-excluder in a queen-right colony. The bees will take care of all queens until they are needed for shipment with package bees. The queens need not be held for more than 24 hours before being placed in the packages. This method is far quicker than where queens are shipped in provisioned cages in which from 10 to 12 attendants also have to be placed. The smaller cages provide the queen with ample room without the disturbances of attendants continually crawling over her. The queen should be confined to the cage by a metal disc rather than a cork, for bees sometimes gnaw away the cork and release the queen in transit.

CRATING THE SHIPPING CAGES.—For several years the majority of California shippers have shipped their packages in crates of five shipping cages, using from three to five 40-inch laths. The center lath on top serves to hold the feeder cans in place; and each crate, or bundle as it is termed by the express company, is greatly strengthened by the stout cord

or flexible wire tied around the center and bottom laths near the ends. The express handlers invariably pick up the crates by this center lath, and this reinforcing cord prevents the center lath from being loosened.

Table 1.—Temperature records of representative packages and of the express car taken in transit. The shipment of bees left Sacramento on train 16, at 10:10 a.m., May 3, 1935.

Date	Time	Shipment No.	Temperature (°F) of Packages					Temperature (°F) of Car		Av. Temp. (°F) of Packages
			1	2	3	4	5	Front End	Near Center	
5/3/35	11 a.m.	4	91	93	93	93	92	77	74	92.4
	1 p.m.	4	92	96	95	95	96	82	79	95.2
	2 p.m.	4	94	95	95	95	94	81	82	94.6
	3 p.m.	4	95	96	97	96	96	85		96.
		18	94	90	92	94	90		85	92.
	4 p.m.	4	95	97	96	97	96	87		96.2
		18	94	90	94	96	91		85	93.
	5 p.m.	4	95	96	96	97	96	84	81	96.
		18	94	92	94	96	90	81	84	93.2
	6 p.m.	4	94	95	95	97	96	82		95.4
		18	91	90	92	93	90		77	91.2
	8 p.m.	4	91	92	93	93	92	68		92.2
		18	90	88	90	90	90		70	89.6
	10 p.m.	4	90	90	88	90	89	62		89.4
		18	88	88	88	84	86		64	86.8
5/4/35	12:30 a.m.	4	88	90	88	88	90	50		88.8
		18	88	86	88	88	82		50	86.4
	1:30 a.m.	4	90	91	88	90	91	53		90.
		18	89	86	89	90	86		58	88.
	2 a.m.	4	90	91	88	90	92	55		90.2
		18	90	86	90	90	86		61	88.4
	3 a.m.	4	90	91	89	91	92	54		90.6
		18	89	86	88	88	86		60	87.4
	4 a.m	4	90	91	89	90	90	56		90.
		18	90	84	88	88	86		58	87.2
	5 a.m.	4	89	92	91	90	90	54		90.
		18	88	84	86	88	84		59	86.
	6 a.m.	4	90	91	89	90	90	54		90.
		18	89	84	86	90	84		58	86.6
	11:45 a.m.	5	94	94	92	94	94	77		93.6
		13B	90	86	90	92			80	89.5
	12:45 p.m.	5	96	98	97	96	98	81		97.
		13B	92	86	90	94			84	90.5
	1:45 p.m.	5	95	98	95	96	96	83		96.
		13B	94	88	94	96			85	93.
	3 p.m.	5	96	96	95	96	97	86		96.
		13B	92	89	92	97			86	92.5
	4 p.m.	5	96	97	96	97	97	87		96.6
		13B	94	92	94	96			86	94.
	5 p.m.	5	96	97	95	99	97	84		96.8
		13B	94	90	92	96			84	93.
	6 p.m.	5	95	96	95	97	97	85		96.
		13B	93	88	92	98			83	92.7
5/5/35	12:35 a.m.	5	93	93	92	94	92	76		92.8
	4 a.m.	5	92	91	90	92	68			86.6
	5:30 a.m.	5	91	90	90	88	66			85.
	8:15 a.m.	5	83	95	97	95	92	68		92.4
	9:30 a.m.	5	84	90	96	94	91	72		91.
	10:30 a.m.	5	96	98	96	95	93	76		95.6
	11:30 a.m.	5	92	99	98	98	94	78		96.2
	11:45 a.m.	5	91	97	96	96	94	77		94.8
	2:15 p.m.	5	91	99.5	97	96	94	78		95.5
	4 p.m.	5	91	96	97	96	96	78		95.2
	5 p.m.	5	92	96	97	100	96	76		96.2
	5:30 p.m.	5	93	96	99	96	97	76		96.2

Five laths are better than three, since the two laths nailed along the top ends of the cages protect these edges from being broken in transit.

Observations of package bees in transit.—The majority of package bees shipped by express arrive at destination in a satisfactory condition, and adjustments are made for any that are killed because of negligent handling by the carriers. Many beekeepers have complained, however,

that a certain percentage of the queens shipped with package bees are superseded during the first season or in some cases become drone layers.

In order to learn something of the environmental conditions to which package bees are exposed in transit and at time of installation in their hives, the writer accompanied a shipment[1] of package bees shipped from various points in California to representative destinations in Alberta, Can. In all, 749 packages of bees were observed at different points between Davis, Calif., and Lethbridge, Alta. The temperature to which the queens were exposed was checked by mercurial thermometers inserted through the tops of representative packages with the bulb of each at the same height as the queen. The readings recorded at intervals throughout the journey are given in table 1.

The packages were transferred at Sacramento, Portland, Spokane and finally at Yahk. The ventilation and space provided between Sacramento Portland and between Yahk and Lethbridge was all that could be desired. Both space and ventilation facilities, however, could have been improved from Portland to Yahk. Smoke in the express cars was not a problem at any time. The bees were given no extra food or water.

Among the different crates in this shipment were included a number of crates made up of four instead of five shipping cages. This method permitted a space of 6 inches between each package when 40-inch laths were used, just doubling the space between the cages in a five-package crate.

Reaction of the Package Bees to Temperature.—As is indicated in table 1, the temperature of the various cars at no time during the trip exceeded 87° F nor fell below 50° F. The ventilators and doors of the express cars were opened or closed at various times during the journey whenever temperature conditions seemed to warrant and steam was turned on during the first night at intervals until the temperature of the car was raised from 50° F to between 58 and 60° F.

The temperature of the packages in the vicinity of the queens ranged between 83 and 100° F and fluctuated directly with the temperature of the car. During the first two days the temperature of the cars varied from 50 to 80° F while the cluster temperature near the queen varied from 83 to 96° F. The activity of the bees varied quite noticeably with the temperature of the car and an increase in the activity of the caged bees directly affected the recorded temperature of the thermometers. The bees were more restless when the temperature within the cage went above 96° F than at lower temperatures. It is interesting to note in table 1 that the cage temperatures never went above 95° on the first two days when the car temperature was 80° F or below, while on the third day temperatures of 95 to 100° F were reached at car temperatures of 68 to 78° F. This increase in temperature of the cages was due to increased restlessness on the part of the bees induced evidently by the effects of continued confinement.

The bees clustered tightly when the temperature of the car fell to

[1] The writer wishes to acknowledge the splendid cooperation with the University of California of members of the California Bee Breeders Association, The Railway Express Agency, The Canadian Pacific Railway Company, and Mr. S. O. Hillerud, in making this investigational trip.

50° F on the night of the third. At this time the cluster of many of the 2-pound packages drew away from the feeding area of the feeder can. At temperatures between 58 and 70° F in the car and sometimes to 76° F the bees in all cages hung in loose clusters or clung quietly to the walls of the cages while the train was in motion. At these temperatures the hum of the bees was low and pleasant. As the temperature increased above 76° F the bees became increasingly active. When the train stopped, the activity of the bees increased immediately and if the temperature was 80° F or above, the sound made by the fanning bees was higher and often increased in volume to a loud roar. Shortly after the train started, however, the bees became quieter and the temperature dropped back to where it had been before the train stopped. The operation of ceiling fans might add materially to the comfort of bees at train stops.

When the bees were clustered at temperatures around 50° F, the clusters were always formed around the queen cage and generally included the entire feeder can, except in the case of some of the 2-pound packages as has been mentioned. At 60° F all clusters covered the feeder cans. These reactions might indicate a temperature of 60° F as a safe minimum for all sizes of packages.

The difference in temperatures recorded for packages in crates having 3-inch spacing (shipments Nos. 4 and 5) and those with 5½ to 6-inch spacing (shipments Nos. 18 and 13B) may be highly significant in determining the best method of crating. In every instance, packages having the wider ventilation were between 1.8 and 7 degrees cooler than those with the narrower spacing. This factor might be even of greater value during seasons when temperature conditions are less favorable than those obtaining during the present investigation.

Temperature to Which Queens are Exposed under Normal Conditions.—Preliminary investigations at the University of California indicate the temperature to which queens are normally exposed in a colony during the summer period to be comparatively constant, ranging between 94.5 and 97° F, when the outside temperature in the shade varied from 63 to 100° F. When temperatures in the brood chamber of a hive in the sun were taken, the temperatures ranged from 93.5 to 99° F when the air temperature varied from 88.5 to 115° F. Dunham (*1*) reported an even more constant temperature of between 92.8 and 94° F in the brood area of a colony under modified summer conditions in Ohio.

The temperatures to which the queens were exposed in the packages were somewhat comparable to these records. Under normal conditions bees have access to water and honey and are able to provide ventilation and to regulate not only the temperature but also the humidity of their hives to a remarkable extent. The effect of confinement, especially without adequate ventilation, at a slightly higher than normal temperature for a period of several days may make the results of heating more severe than under hive conditions. There is apparently no more abnormal amount of supersedure of queens in colonies located in the warmer portions of the United States than in those of more moderate temperatures.

Installation of package bees.—When the shipment of package bees

referred to arrived in Lethbridge, the weather was fairly cool; many of the packages were installed during a snow storm. The hives were cold, and the combs on which the bees were installed were cold. Under such conditions the queens were exposed to approximately freezing temperatures for a few minutes to several hours; in some cases, 24 hours after a package had been installed, the bees had not left the shipping cage to cluster around the queen. Such conditions may be unusual, but it was deemed worth while to determine to what extent continued exposure to

Table 2.—Data concerning queens exposed to cold at the university farm to determine the relation of such exposure to supersedure.

Nucleus No.*	Date Chilled	Hours of Exposure	Temperature (°F) Exposed	Remarks
2B	6/20	½	34	Apparently normal September 26.
5B	6/20	1	34	Apparently normal September 26.
6A	6/20	1½	34	Brood normal September 26.
6B	6/24	3½	34	Normal on August 18.
8A	6/24	3½	34	Some drone brood in worker cells September 26.
17A	6/24	5	34	About 10 per cent of bees emerged as monstrosities, bodies normal, heads deformed.
17B	6/24	5	34	Brood normal August 18, but queen had been superseded by September 26.
1C	6/27	5	34	Brood normal September 26.
2C	7/27	5	34	Queen missing on September 19, with much drone brood in worker cells among normal brood.
22A	7/1	8	34	Queen laying regularly on July 21 but had disappeared by August 14. Some drones in worker cells.
8B	7/27	24	34	Queen and brood apparently normal on August 26.
8C	7/27	24	34	Queen laying erratically; much drone brood in worker cells by September 26.
14B	7/1	24	34	Queen laying erratically; supersedure cell started on August 18.
17C	7/27	¾	20	Queen laying by August 1, on August 17 was *very* old looking, died on August 18. All eggs that hatched produced drones.
22C	7/1	8	34	Superseded by September 19.

* Several other queens than those listed above were exposed to cold but either did not recover completely or were killed at time of introduction. All queens were marked and clipped and had been laying for some time before exposed to cold.

either cold or heat would have on the general physiology of the queen and particularly upon her fecundity.

Effect on Queens Exposed Artificially to Cold.—A number of queens were exposed to cold temperatures for varying periods at the university farm, Davis, and then introduced into nuclei. The queens were first caged for three days in the nuclei and then exposed to a temperature of 64° F before being placed in the colder chambers. After exposure to the colder temperatures, as indicated in table 2, they were again left at a temperature of 64° F until they showed some signs of life before being introduced. The more important results are given in table 2. All were 1935 queens reared in the university apiary.

The results certainly indicate that queens exposed to a temperature of 34° F for as short a time as five hours or for a much lesser period at a lower temperature sometimes are superseded or develop into drone-layers within a comparatively short time. It is possible that had these queens been introduced into normal colonies where they would have had to lay to capacity, they would have "broken down" or been superseded much earlier. It was also evident that the exposure to cold not only killed many of the sperms but also affected seriously the physical condition of the queens, as it made some of them look and act like old queens.

These experiments were terminated when the nuclei and colonies of the experimental apiary were either killed or very seriously injured by airplane dusting in the vicinity. The work will be continued until more conclusive data are obtained.

Suggestions for installation of package bees during cold.—As soon as the packages are received, they should be taken to a room with a temperature above 57° F and fed as much warm sugar syrup as they will take when the syrup is painted on the screened sides of the shipping cage. They should also be protected at all times from the cold drafts by blankets. As queens may be seriously injured by exposure to cold, a method that includes provisions for warming the hive artificially at the time of installation will be beneficial to the bees and protect the queen. This could be done by supplying each hive with a pail of hot 2:1 sugar syrup at the time of installation and by shaking all the bees out of the shipping cage into the hive and closing its entrance to a space of approximately three-eighths by 1 inch. The metal discs of the queen cage should be removed, and the hole filled with a plug of queen cage candy or soft granulated honey. This cage should be suspended between two frames of honey near the feeder pail of warm syrup. The queen will be released within a few minutes, and as she has already acquired the odor of the bees she will be accepted. The hive should not be disturbed until the queen has started to lay, or at least not for five days after she has been introduced.

One simple way of feeding the bees is to place an open pail holding 10 pounds of syrup in an empty hive body below the super containing a full complement of combs. The pail should be filled with straw to prevent bees from drowning. Hot syrup will soon warm up the hive and combs if the top of the hive is closely covered to conserve heat. The empty hive body, the feeder pail, and the queen cage can be removed five days later with very little disturbance. A modification of this method is used successfully by W. A. Finlay, provincial apiarist, British Columbia, and other methods of installing package bees are described by W. A. Finlay (*3*) and C. B. Gooderham (*4*) for Canadian conditions.

The provision of windbreaks and proper arrangement of the hives in the apiary will tend to prevent drifting of the bees from one hive to another. Robbing can be reduced by installing all packages in an apiary on the same day rather than on successive days. If an apiary is to be increased with package bees, the packages should be installed elsewhere and moved in after the bees have become well established. Here also the beekeeper should take precautions to prevent drifting and bees from

being lost by obstructing their entrances with brush. Bees will return to their former locations from a considerable distance when moved in a region in which they have previously oriented themselves (*2*).—8-31-36.

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RELATION OF AIRPLANE DUSTING TO BEEKEEPING

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In a previous report (*3*) the writers demonstrated that the application of calcium arsenate by airplane to tomatoes in the vicinity of the university farm, Davis, had resulted in the death of many colonies of bees because of the poison drifting over adjacent territory. It was determined that bees did not visit the tomato blossoms but were killed by securing pollen and nectar from plants outside of the treated fields on which the poisons had drifted. It was evident that the nectar gatherers died in the field and that the pollen bearers carried the poisoned pollen back to their hives where it killed the nurse bees. Attention was called to much heavier losses in the beekeeping industry and of livestock from similar practices in other parts of the country. The gross symptoms of bees poisoned with calcium arsenate were described and verified by chemical analyses.

General condition of apiaries and flora, 1935.—At the close of the 1934 season, all of the brood combs in the university apiary that contained pollen were soaked in water for 24 to 48 hours and then dried so that the pollen would be removed by the bees instead of being used by them. Twenty colonies that would have died from the effects of poisoning were strengthened with package bees and 30 additional colonies were purchased to replace partially those that had been killed by the drifting poison. The original queens were left in the 20 colonies.

Climatic conditions were very favorable to plant growth during 1935 and the nectar and pollen plants were above average for the region; the yellow star thistle, *Centaurea solstitialis* L., and the alkali weed, *Centromadia* spp., being particularly abundant. Colonies built up rapidly in the spring, being stimulated by nectar and pollen from mustard and fruit bloom, including a majority of those headed by the 1934 queens,

[1] The chemical analyses and determinations were made by Mr. H. W. Allinger, analyst, Division of Chemistry, University of California. Mr. Frank E. Todd and Mr. George H. Vansell, of the Pacific States Bee Culture Field Laboratory, U. S. Department of Agriculture, cooperated in making observations on the effects of poisoning on the colonies in the federal apiary. Mr. George J. Triphon and Mr. William Baker assisted in making observations concerning their own apiaries.

thus demonstrating that the queens apparently had not been injured by the poisoning episode. By August 1, 1935, there were 373 colonies of bees and 62 nuclei in the five apiaries in the area shown in fig. 1. These were distributed as follows: University apiary, 52 colonies and 62 nuclei; U. S. Pacific Coast Bee Culture Laboratory, 49 colonies; William Baker, 37 colonies, and George J. Triphon, two apiaries, indicated at D and E on the map, with about 137 and 98 colonies, respectively. Mr. Triphon also had a third apiary east of the one indicated at D.

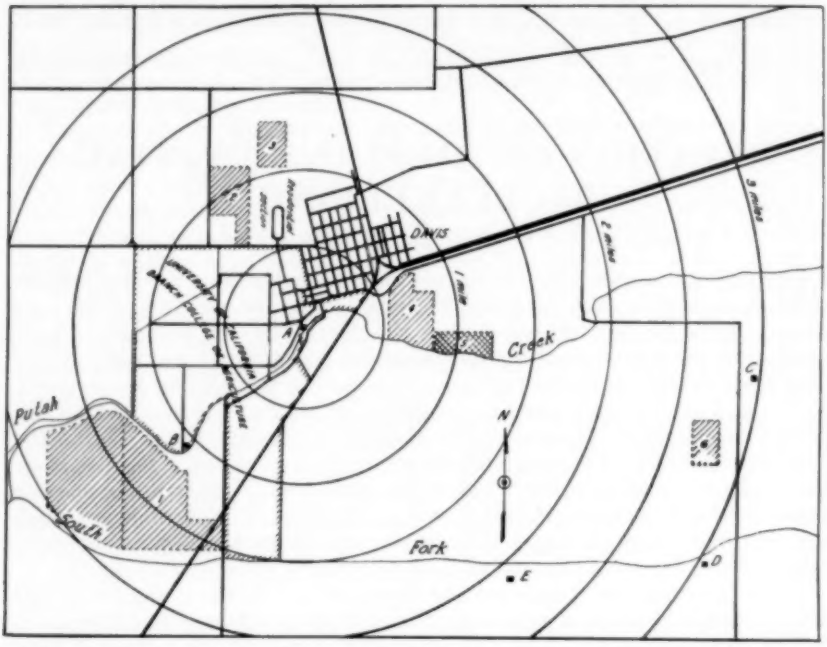

Fig. 1.—The approximate location of apiaries in relation to the tomato fields over which calcium arsenate was applied by airplane. A, apiary of the University of California; B, apiary of the Pacific States Bee Culture Field Laboratory; C, home apiary of William Baker, and D and E, commercial apiaries of George J. Triphon. Field No. 1 was three tracts operated by three separate companies or individuals. Field No. 5 was treated by land applicators only.

The tomato acreage was increased over that of 1934 and was located approximately as shown in fig. 1. The tomato fields were practically free of all weeds of any consequence in their attraction to the honeybee.

The nectar flow began on July 16 and the scale colony in the university apiary gained 2 to 5 pounds in weight on each favorable day thereafter during the nectar flow except as noted later. More than half of its total gain was stored before August 8. All normal colonies occupied two to four stories and each had a normal amount of brood. There was no evidence of any adult or brood diseases or poisonous plants in the area to reduce the strength of colonies to any appreciable extent.

Applications of calcium arsenate by airplane in 1935.—When we were notified at the university farm August 4 that the fields would be dusted by airplane with calcium arsenate on the following morning, we foresaw a destruction of our colonies and experimental work similar to that caused by the drifting of poisons that were broadcast in 1934. It was decided, however, to make observations somewhat similar to those of 1934 in order to check previous records. Approximately two-thirds of the colonies were to be closed in the university apiary, the rest to be left open as a check on this method. The nuclei could not be closed with

Table 1.—Broadcasting of poisonous dusts over tomato fields by airplane in the vicinity of the university farm, Davis, Calif., 1935.

Date	Location of Field	Approximate Acreage Treated	Pounds of Poisonous Dust	Kind of Poison	Prevailing Direction in Which Poisons Drifted
Aug. 8	1* Central portion	40	800	Calcium arsenate	Variable, changing from W. and S.W. to E. and N.E.
Aug. 9	1* Central portion	100	2000	Calcium arsenate	E. to S.E.
Aug. 18	4	60	1200	Calcium arsenate	S.W. to W.
Aug. 19	4	10	200	Calcium arsenate	E. to N.E.
	1	167	3540		E. to N.E.
Aug. 20	2	45	900	Calcium arsenate	N. to N.E.
	3	35	700		
Aug. 20	6	35	700	Sodium fluosilicate	East
Aug. 27	1	75	1500	Calcium arsenate	North
Sept. 10 and 11	2	45	900	Calcium arsenate	E. to N.E.
	3	35	700		
	4	67	1500		
Sept. 15 and 16	1	150	3000	Calcium arsenate	E. to N.E.
Oct. 9	?	?	700	Calcium arsenate	

* Field 1 consisted of 3 separate tracts operated by as many individuals or companies and comprised about 450 acres.

safety, due to the high temperatures then prevailing. The various broadcasts of poisons occurred approximately as shown in table 1.

Three airplane companies were involved in making the different broadcasts of poisons, the first company making applications on August 8 and 9, the second company applying the materials on August 18, 19, 20 and 21, while the rest of the treatments were made by the third company. The airplanes were flown from 5 to 15 feet above the vines while releasing the poisons over the fields. Each application was accompanied by a considerable drift of the poison in the form of a dense cloud of dust that extended to a height of 30 feet or more, the amount of drift increasing with the height at which the poison was released, fig. 2. The drifting poisons were sufficiently heavy to be seen conspicuously at a distance of two to three miles from the point of application at different times when such observations were made. In every case the air over the field to which

application was made was cleared of the dust in less than 15 minutes after the operation had ceased and at times within as short a period as five minutes. Each plane, and particularly those of the first two companies, left a heavy trail of dust as it was maneuvered back to the field at the end of each lap.

The pilots invariably opened the dust compartment when 30 feet or more above the field on every approach excepting in rare cases when the airplane could be leveled off before reaching the field. The distribution of poison was seldom shut off until after the planes had been turned sharply upward on leaving the fields. Both of these maneuvers materially influenced the amount of poison distributed over adjacent fields.

It was also observed that the dusts hung much lower to the ground when the temperature was below 56° F and rose rapidly in the air at temperatures above 60° F.

Fig. 2.—An airplane broadcasting calcium arsenate 15 or more feet above a tomato field, one reason why such great quantities of poisons always drift over adjacent territory. The drifting poisons are visible in the background.

Previous to an application on August 20, the pilot momentarily opened the dust compartment of his airplane while over an alfalfa field on approaching the field he was intending to dust, resulting in the distribution of a heavy cloud of poison at that spot. The same pilot on returning to the landing field after applying sodium fluosilicate to field No. 6, cleared his plane of a considerable quantity of the poison remaining while at a distance of more than one-half mile from the field for which the poison was intended. On this same day the wind was blowing strongly enough to clear each field within five minutes after the applications were made. Such performances add greatly to the amount of poison that drifts over adjacent territory, to the detriment and inconvenience of others.

In returning to certain of the fields, the pilots had to circle low over residential property and the trail of dust that followed, together with the nearness of the flight over the homes, caused considerable inconvenience and apprehension to the owners. The direction of the prevailing wind, power lines and trees may have controlled the direction of flight and this situation is mentioned here simply to call attention to the danger to property encountered when an attempt is made to treat small acreages adjacent to residential districts. The drifting poison is a factor

that cannot be controlled when the airplane is used and consideration of this fact should be taken into account by the different companies in broadcasting poison under such circumstances.

Detailed observations of each individual flight or application would simply be a repetition of the facts mentioned above, although they might tend to emphasize the gross carelessness often involved in the practice and the grave danger that is connected with the drifting poisons when such a method of pest control is attempted without official supervision or regulation in diversified agricultural districts and in residential sections.

Table 2.—Analyses of samples of bees, brood, pollen and plants for arsenic.

Sample No.	Origin of Sample	Date of Sampling	Kind of Sample	Weight of Sample *grams*	Arsenic Found as $Ca_3(AsO_4)_2$ *parts per million*†
1	U. C. apiary	8/21	Bees, crawlers*	5.	16.
2	U. C. apiary	8/21	Pollen, Colony No. 54	9.	23.
3	U. C. apiary	8/21	Crawlers*	7.	29.
4	U. C. apiary	8/23	Larvae	10.	12.
5	U. C. apiary	8/23	Larvae	10.	13.
6	U. C. apiary	8/23	Pupae	10.	10.
7	Triphon's apiary	8/28	Pollen	4.	25.
8	Triphon's apiary	8/28	Pollen	4.	30.
9	Triphon's apiary	8/28	Dead bees	6.	25.
10	1 mile from area dusted	8/27	Wild sunflowers	9.	6.
11	1 mile from area dusted	8/27	Turkey mullein	3.4	14.
12	Near woodland	8/29	Sugar beet tops	9.5	1420.

* The crawlers were young bees that had just left their hives under the stimulus of arsenical poisoning.
† Approximately one-half part of arsenic per million is a lethal dose for bees under normal conditions.

Observations on dust movements.—The poison dust is released through a sliding trapdoor in the bottom of the plane, the aperture being controlled by a lever operated by the pilot. The dust falls into a chute or venturi tube and is driven backward by air currents generated by the propeller and dispersed by the air movements of the plane which is driven at an average speed of about 100 miles per hour. The dispersion of the dust is also controlled somewhat by the shape of the venturi, as well as by such factors as the distance the dust is released above the ground, by the wind, air temperature, humidity, and heat radiation from the ground. When the dust is released as the plane glides downward in approaching a field, the dust is forced downward and spots the ground and foliage; conversely, the dust is pulled upward when the plane leaves the field. The dust that trails behind the plane after it leaves the field depends either on the amount of dust left in the venturi, or on imperfect mechanical operation of the trapdoor, or both.

To observe the movement of the dust in greater detail, an observer took a position beneath the plane on several occasions as the dust was being applied on August 18. The tops of the tomato vines were barely moved by air currents when the plane was at a height of 10 to 15 feet.

The calcium arsenate spread backward, downward, outward, and then upward and inward in swirling circles. It appeared that less than half of the total volume of dust released ever reached the vines or ground and much that did was subsequently sucked upward by vortices at the wing tips of the plane.

Chemical analyses.—To check the amount of drift in relation to the total dust applied, four 18 by 18-inch and two 18 by 30-inch glass plates, each vaselined on one surface, were placed in open spaces 20 paces apart across field No. 8 on August 18 with the line of plates at right angles to the direction of flight. Five 5 by 8-inch plates with vaselined surfaces downward were placed among the foliage of the tomatoes. Two 18 by 30-inch vaselined plates were placed on top of hives in the university

Table 3.—Analyses of arsenic caught on vaselined glass plates during application of calcium arsenate by airplane to field No. 4 on August 18.

Serial Nos. of Plates Exposed	Plate Dimensions	Plate Area	Arsenic on Each Plate Calculated as $(Ca_3(AsO_4)_2$	Arsenic Applied per Unit of Surface	Ratio Between Amount Applied and Amounts Captured on Plates
	inches	*square feet*	*milligrams*	*milligrams*	*per cent*
1	5× 8	.2778	.0302	40.94	.074
2	5× 8	.2778	.0604	40.94	.148
3	5× 8	.2778	.0805	40.94	.197
4	5× 8	.2778	.1207	40.94	.295
5	5× 8	.2778	.0805	40.94	.197
6	15×18	1.875	122.7	276.37	44.4
7	15×18	1.875	61.35	276.37	22.2
8*	15×18	1.875	241.7	276.37	87.4
9	15×18	1.875	161.8	276.37	58.5
10*	15×30	3.126	504.2	460.77	109.3
11*	15×30	3.126	463.	460.77	100.3
12*	15×30	3.126	.221		
13*	15×30	3.126	.221		

* The airplane passed directly over plates 8, 10 and 11, while plates 12 and 13 were exposed in the university apiary three-quarters of a mile from the field treated.

apiary to indicate any drift of poison in that direction. The airplane passed directly over plates Nos. 8, 10 and 11 and at least two of the smaller plates which were located in the same relative positions. The analyses of materials caught on these plates are given in tables 2 and 3.

The analyses for arsenic were made according to the Methods of Analyses, 3rd Edition, 1930, (*5*) with one change. The addition of potassium iodide was omitted and the reduction of arsenate to arsenite in the Gutzeit reductor carried out with stannous chloride alone, thereby securing much more concordant results. The dead and crawling bees were analyzed as received, no attempt being made to remove externally adhering poison, if any. The wild sunflower and mullein specimens only were dried and the results based on the dried weight.

The beet tops were brought in by a cattle feeder, the sample being taken about 100 feet from the tomato field that had been dusted by airplane.

The results of the analyses, as given in tables 2 and 3, indicated vary-

ing quantities of arsenic in the dead and dying bees, larvae, pupae, pollen, and the two flowering plants. The plants were collected at a distance of 1 mile from the field over which the calcium arsenate was broadcast. The amount of arsenic in the pollen stored in the combs was sufficient to cause the death of many bees and much brood and is definite evidence that combs in which poisonous pollens are stored will continue to cause the death of bees and brood until removed or all is used. The effects of this poisoned material may be evident for months after it has been gathered and is the cause of much spring dwindling of colonies so affected.

The fact that the pupae contained such large amounts of arsenic indicates that the larvae were fed food containing arsenic near the close of their feeding period and the effects were not fatal until after metamorphosis had been partially completed.

Exposure of the vaselined plates gave interesting data concerning the unevenness of the applications, the small amounts that can be expected to be left on the under surfaces of the leaves and fruit and the large amounts that must necessarily drift from the field. The small amount of arsenate caught on the inverted 5 by 8-inch plates indicates further that the so-called "rebound" of the calcium arsenate from the ground and the resulting deposit on the under surfaces of the leaves and fruit (a point in the sales talk of many interested in the promotion of airplane dusting) is more of an hypothesis than fact, at least in the case observed. The vaselined surfaces would certainly hold far more of the arsenic than the smooth areas of the ripened or green fruit or even the leaf surfaces.

The two plates that were placed in the university farm apiary, three-fourths of a mile from the field treated, caught sufficient arsenic to kill a large number of bees and demonstrated the seriousness of such drifting poisons from the viewpoint of the beekeeping industry.

Some effects of the drifting poisons.—By the afternoon of August 8, on which the poisons were first broadcast, crawling, hopping and dead bees were found in different parts of the two apiaries on the university farm, fig. 3. The first heavy mortality, however, followed the dusting of field No. 4 on August 18 and 19. Some colonies were more seriously affected than others with no noticeable difference between the colonies that had been closed and those left open. This phenomenon prevailed following each application. Colony No. 53 in the university apiary, for instance, was killed outright by poisoning, while No. 54, immediately adjacent, was not very seriously injured. Neither had been closed. Colony No. 1 was reduced about 75 per cent while No. 2 was not seriously affected, and both were closed. Those colonies most seriously affected had worked in areas over which the poisonous dusts had drifted, while the others had gathered in poison-free areas. This explanation is in line with data presented by Eckert (*2*) following studies in the orientation of bees in gathering nectar and pollen. By August 21, many colonies and nuclei had been reduced by at least 50 per cent, and practically all unsealed larvae in the affected colonies had either disappeared or were dead in their cells.

Some days later, pupae and bees about to emerge were found dead in all colonies seriously poisoned. These symptoms persisted throughout the summer. In 1934 this condition was thought to be occasioned by starvation and neglect but the chemical analyses in 1935 indicated that the older larvae, at least, had died of poisoning. The pupae and adults that died may have been fed a sufficient amount of arsenic late in their feeding period to prevent complete metamorphosis.

George J. Triphon reported a general reduction of field force in his apiaries with an accompanying reduction in the honey crop and espe-

Fig. 3.—The accumulation of dead bees in front of a hive in the federal apiary on the university farm. This represents a case of extreme poisoning as usually the bees die in a manner as to leave practically no accumulations of dead bees near the hive.

cially in certain colonies located at E, fig. 1. Since the apiaries at E and D were between 1.75 and 2.5 miles from field No. 4 and 2 and 3.25 miles from field No. 1, respectively, it is evident that the dust drifted for considerable distance in the direction of these apiaries to make it possible for the bees to get the amount of poison to cause the damage noted. The fact that the poison drifted from these two fields in a manner to cause its concentration in an area northwest of apiary D tended to increase the danger of poisoning to the bees in this apiary. Mr. Baker's colonies apparently were not seriously injured.

QUEEN BEES AGAIN NOT SERIOUSLY AFFECTED.—Since the queen bees are fed by the nurse bees and are presumed to receive much the same kind of food as the younger larvae, it is difficult to explain why they were not killed when so many larvae were poisoned. Could it be that their food is still more "refined" and that only those bees that did not use poisoned

pollen in the process lived to feed them? Larvae were also found dead in sealed queen cells.

By October 15, in the university apiary, only 12 to 15 nuclei remained of the original 62, 12 having been killed outright and the rest reduced to a mere handful of bees. Six colonies had been killed, 17 were reduced to eight frames of bees or less, 21 had only 10 frames of bees, two were only slightly injured, and six colonies were apparently uninjured. The federal apiary was almost destroyed, only four colonies remaining with five or more frames of bees and these colonies still showed evidences of poisoning in the brood area. This apiary was in direct line of the drifting poison on two occasions but whether this augmented the injury or not could not be determined.

The amount of honey produced in the federal apiary approximated 240 pounds, although normal expectation, judging from the production of the few colonies in the university apiary not seriously affected, should have been not less than 4000 pounds. Colonies in the university apiary produced an average of 31 pounds instead of 85 pounds or better, which was the average production of the six colonies that were apparently uninjured by the dusts. The best university colony produced 129 pounds. The scale colony produced a surplus of only 44 pounds and before the dusting operations began it was equivalent to any colony in the apiary in number of bees and amount of brood. This loss of crop due to a reduction of colony strength is a serious matter in commercial honey production.

Adverse public reaction to airplane dusting.—During the summer a feeder of beef cattle brought to the Chemistry Division some beet tops from a field adjacent to one treated by airplane with calcium arsenate. The tops were whitened with the poison and were said to be a fair sample from the field. He wanted to know if it would be safe to let his cattle feed on the tops and beets that had been left after the crop had been harvested. Dairymen in the vicinity have expressed grave concern in regard to the effects of the accumulations of heavy applications of poisons drifting over their pastures and hay fields.

An instance of what can happen in this regard occurred during the present applications. Three dairy cows that fed on alfalfa in a field adjacent to field No. 2 became quite sick soon after the tomatoes had been treated with calcium arsenate by airplane. All three cows lost weight and the milk supply was greatly reduced, two of the cows being unable to furnish sufficient milk for their calves. The cows had made partial recovery in milk production but were considerably below normal weight two months after the first effects of poisoning were noticed. The symptoms were observed and diagnosed by two veterinarians as arsenical poisoning.

Residents in the path of the drifting poisons and over whose homes the airplanes pass at very low elevations are not only seriously disturbed but are quite apprehensive of the practice from a health viewpoint. Some have even taken out insurance against damage by the airplane operations. Many are asking why the airplane is used by some growers while others find it unnecessary or even ineffective, and what steps can

be taken to stop the practice at least in diversified agricultural areas and in fields adjacent to residential sections.

It should be stated that the practice of airplane dusting with poisons is not confined to the isolated district described herein or to California but is used in other sections of the country and seems to be spreading rapidly. The practice is not confined to large acreages or to any given crop although some of the older and more reliable dusting companies do refuse to apply poisons in areas and under situations where damage is liable to result. The absence of proper regulatory and control measures and the lack of adequate supervision of poisons used, rates, methods and conditions of application open the field to practically any pilot of an airplane who can secure a commercial pilot's license.

That the unregulated use of poisons may result in sickness and even death to people, under certain conditions, is emphasized in a recent report by the Berlin correspondent of the Journal of American Medical Association (*1*). Another German authority (*4*) states that the drifting poisons are dangerous to bees within a radius of 6 miles when airplanes are used to apply dusts. It is also conceivable that if the drifting poisons are sufficiently strong seriously or fatally to affect dairy cattle in adjoining fields, they may cause serious disturbances to the human system, especially in the case of children.

Many indications point to the fact that the public is becoming much more than mildly interested in the tons of poisonous materials that are being applied unethically and needlessly in an attempt to find an easy method of controlling insect pests.

Suggested remedies.—The beekeeping industry has suffered heavy losses for many years from the application of liquid sprays or poisonous dusts to growing crops from which the bees gather pollen or nectar while rendering an invaluable service in effecting the proper pollination of the blossoms. It would be impossible to raise many of our fruits and seed crops without this natural function of the honeybee. Beekeepers have moved out of many such areas because they recognize the right of any grower to protect his interests against insect depredations. However, when the poisons are applied in such a manner that they are not confined to the area treated but drift for great distances beyond and in such quantities as to cause the irreparable destruction of other property, the issue assumes a different aspect entirely in that the property rights and privileges of individuals are affected. The injured parties have recourse to law but the solution is even more fundamental than this. From an entomological as well as a humane viewpoint, should not those entrusted with the responsibility of recommending, regulating, or of enforcing certain practices involving the control of injurious pests refuse to recommend or countenance any practice that is unethical or that may cause serious or irreparable loss or injury to the property rights or freedom of parties other than those engaged in such practices? And when application is made by commercial outfits, should not the grower himself be adequately protected against loss due to the carelessness, ignorance and poor equipment of the applicators?

Land applicators of liquid sprays cause no material drifting and can

be regulated to put the poisons where they are most needed and at a time when injury is imminent. Such methods may be slower and may even change certain cultural practices but they give more efficient results. The use of preventive measures, such as the control of weeds that serve as host plants for the injurious insects, certain types of cultivation, rotation of crops, trap crops, poisoned bait and light traps, can be put into practice with beneficial results.

The ultimate control, therefore, is the prohibition of the application of any poison by any method that will not confine the poison to the area treated when such poisons may cause irreparable loss to the property or rights of other individuals or react against the public health and interests.—8-31-36.

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LABORATORY AND FIELD TESTS OF CHLORINE TREATMENT OF HONEY COMBS[1]

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History of control methods for American foulbrood.—Early attempts at controlling the infectious brood disease of honeybees now known as American foulbrood did not involve saving the combs but the adult bees. Jacob in 1568, according to Betts (*2*), advised cutting out affected comb and starving the bees. Various modifications of the starvation principle have been used ever since, usually together with transference to new equipment by shaking or other treatments. Dunham & King (*9*) compared various methods of shaking and checked their field tests with bacteriological studies. Some recurrence was noted with each method. Numerous drug treatments were tried in Europe, phenol being proposed as early as 1874 by Butlerow (*12*). Fumigation treatments also came into prominence in the late nineteenth century, many volatile compounds being left inside the hive supposedly to effect a cure although the concentrations used were not strong enough to kill even the bees. Such a process using salicylic acid was introduced by Hilbert in 1875 (*4*). The

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[2] The writer wishes to express his sincere gratitude to Dr. M. C. Tanquary under whose guidance this investigation was conducted.

next step was the use of fumigants and disinfectants in concentrations intended to sterilize the combs and equipment of the hive without attempting to save the bees. Sturtevant (*24*) and Gilbert (*10*) give brief reviews of such treatments. Most gases tried were found ineffective. Hutson (*13*) found that chlorine gas killed the spores within 24 hours and that labor costs were low, but the honey was poisoned for the bees and exposed metal parts were corroded. Bees did not readily accept the treated combs. Many disinfecting solutions have been tried, the first apparently real success being reported by Hutzelman (*14*) in 1922 with an alcohol–formalin mixture. Formalin has since been used in combination with numerous other spreading solutions but Sturtevant (*24*) from a thorough comparison concluded that a 20 per cent solution of formalin in plain water was the most satisfactory with regard to germicidal action and cost. He emphasized the precautions needed, such as the uncapping of all cells and extraction of honey to insure penetration of the disinfectant.

Use of chlorine compounds in solution for disinfecting combs appears to have started with the work of Wilson & Hadfield in 1923, who reported (*30*) success with hypochlorite solutions, from both laboratory and field tests. However, Jones (*15*, *16*) found chlorozene and a hypochlorite sold specificially for disinfecting combs under the trade name *Be-Health*, to be ineffective. Mr. H. G. Ahrens, at an entomology seminar at the University of Minnesota in the spring of 1931, reported success with a calcium hypochlorite solution, but another treatment seemed more promising. This was the soaking of uncapped combs in water through which chlorine gas was allowed to bubble for three days. These treated combs had been placed in package-bee colonies and had been accepted readily. No recurrence was detected by the end of the summer and a brief announcement of the new treatment was given by Dr. Tanquary in the two leading bee journals (*26*, *8*). More detailed directions were published in 1932 (*1*). The main advantage was the relatively low cost, and many beekeepers decided to give it a trial. It was not long before complaints were being raised. Dadant (*6*, *7*) wrote editorials advising against it use. Cushman (*5*) reported difficulty in controlling the dosage, bleaching of the wax, corrosion of wires, an effect on paint, and a persistence of odor which made the bees slow in accepting the combs and sometimes gave a taste to the honey stored in them. In the fall of 1932 the returns from a questionnaire sent to numerous beekeepers who had tried the chlorine treatment indicated a marked variation in its effectiveness as applied under different conditions. Morehouse (*22*) found that while the treatment sterilized the combs, the odor so repelled the bees that the honey yield in a commercial apiary was greatly decreased. Hambleton (*11*) in a government publication on the treatment of American foulbrood advised burning the combs and bees and scorching the empty hives, a treatment long recognized as the safest way to prevent spread of the disease to other colonies. He considered the chlorine treatment disappointing and the gas dangerous to handle. Braun (*3*) found the odor of chlorine persisted longer than that of formalin, breakage of combs was greater in the chlorine treatment, and though cheaper than the water–formalin or

alcohol–formalin treatments, the chlorine treatment was more expensive on a small scale than the purchase of new equipment. Some recurrence of disease was had with all three methods, and honey yields were reduced.

It is thus seen that the methods used in attempting to control American foulbrood have included starvation and shaking treatment to save adult bees, drug and fumigation treatments to save the entire colony, and the use of fumigants and disinfectants to save the combs and equipment. None of the methods, however, have proved entirely dependable.

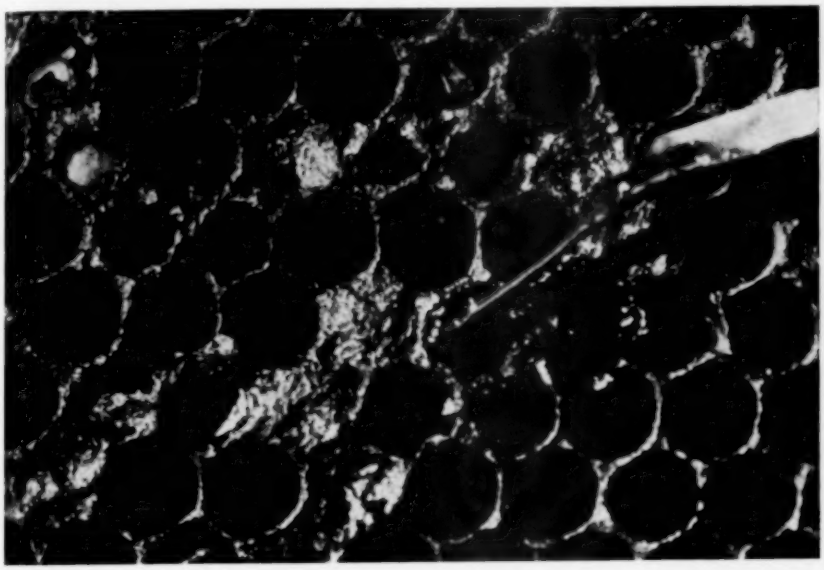

Fig. 1.—American foulbrood, the characteristic dark brown ropy remains stretched out from a cell on the end of a match. (Photo by V. P. Hollis.)

Characteristic symptoms of American foulbrood.—For a detailed description of the symptoms of Americal foulbrood one may refer to the writings of McCray & White (*21*), Lochhead (*18*), and especially White (*28*). The chief characters used in diagnosing the disease by gross appearances are the dark brown ropy or viscous remains which can be drawn out of the cell on the end of a match as shown in fig. 1, or the rightly adhering scales. In sacbrood the dead larva usually remains in a normal position in its cell and the body wall is intact so that the entire larva can be picked out of the cell.

Cultural studies of *Bacillus larvae* White.—*Bacillus larvae* cannot be isolated on the routine bacteriological media. The special media employed by the writer have been White's unheated egg-yolk media and Lochhead's carrot-extract media, adjusted to approximately pH 6.8. Careful descriptions of *B. larvae* have been given by White (*27*, *28*), Sturtevant (*23*, *25*), and Lochhead (*17*, *18*, *20*). Only the most significant

character, that of a positive nitrite test in carrot-extract media, will be discussed here.

Lochhead in 1927 first reported that *B. larvae* gave a marked nitrite test in peptone–carrot-extract media to which no nitrates had been added. The carrot extract itself contained slight traces of nitrates but ordinary nitrate-reducing bacteria, such as *B. cereus* and *Escherichia coli*, failed to produce nitrites in carrot-extract media, though they did so readily in standard nitrate media. Quantitative determinations showed that *B. larvae* increased the amount of nitrites present in peptone–carrot-extract media from .005 mg./100 cc. to as much as .338 mg./100 cc. after two weeks' incubation. He concluded that *B. larvae* produces nitrites by an oxidation rather than a reduction process. In 1928 and 1929 he repeated his statements regarding the nitrite-forming ability of *B. larvae*. Sturtevant in 1932 reported that, of 11 organisms he had tested, most nitrate-reducing species gave positive tests for nitrites in peptone–carrot-extract media within a few hours' incubation, but that in all cases after 48 hours the nitrite test was negative, although the same species still gave positive nitrite tests on standard nitrate media. He found the nitrite test a fairly delicate indicator of the presence of vegetative growth of *B. larvae*. Lochhead in 1933 stated: "A positive nitrite test, even in the absence of visible growth, is strongly presumptive evidence of the presence of viable cells of *B. larvae*."

The writer compared *Bacillus larvae* with *Pseudomonas aeruginosa* and an unknown organism in standard nitrate and carrot-extract broths and on standard nitrate and carrot-extract agar media after incubation at 37° C for 6, 12, 24 and 48 hours. The data are summarized in table 1. The significant feature is that *B. larvae* was the only organism to give a positive nitrite test in carrot-extract broth. *P. aeruginosa* in standard nitrate media not only reduced the nitrates to nitrites but also reduced the nitrites so that after 24 hours' incubation the media were negative for both nitrites and nitrates. In carrot-extract media the nitrite test was always negative with this species. Unknown B3 was a vigorous nitrate-reducer but carried the reduction no further than the nitrite stage, in standard nitrate media; yet in carrot-extract media it never gave a positive nitrite test. Therefore, a positive nitrite test in carrot-extract media seems to be specific for *Bacillus larvae*. The significance of this lies in the fact that[3] *B. larvae* is a spore-forming heterotrophic bacterium, whereas other known nitrifying bacteria, *Nitrosomonas* and *Nitrobacter* spp., are non-spore-forming autotrophic species.

Chlorine treatments.—Two batches of honey combs from diseased colonies were treated with chlorine according to the method devised by Ahrens & Tanquary. All combs were carefully uncapped. The hive bodies were placed in the treating tank with the combs in a vertical position and were held submerged by wooden braces in such a manner that one hive body could be removed every six hours, leaving the others submerged for a longer treatment. The tank was cylindrical with a capacity of about 1000 gallons. The gas passed from the chlorine cylinder through

[3] As pointed out to the writer by Dr. A. T. Henrici of the Bacteriology Department of the University of Minnesota.

Table 1.—Comparison of *Bacillus larvae* with two vigorously nitrate-reducing organisms as to growth, nitrite and nitrate tests in carrot-extract and standard nitrate media.

Organism	Broth Media								Agar Media			
	Standard Nitrate				Carrot Extract				Nitrate		Carrot Extract	
	Hours of Incubation at 37° C											
	6	12	24	48	6	12	24	48	24	48	24	48
	*Growth**											
B. larvae	0†	0	0	?	0	0	+	+	+	+	+	++
P. aeruginosa	0	+	+++	+++	0	+	+++	+++		+++		
Unknown B3	++‡	++	++	++	+	++	++	++	++	++	+++	+++
Uninoculated	0	0	0	0	0	0	0	0	0	0	0	0
	Nitrite Reaction§											
B. larvae	0	0	+	++	0	+	++	++	0	0	0	0
P. aeruginosa	0	+++	0	0	0	0	0	0		++		
Unknown B3	+	++	+++	+++	0	0	0	0	+++	+++	0	0
Uninoculated	0	0	0	0	0	0	0	0	0	0	0	0
	Nitrate Reaction¶											
B. larvae	+++	+++			0				+++	+++	0	0
P. aeruginosa	+++		0	0	0	0	0	0				
Unknown B3					0	0	0	0			0	0
Uninoculated	+++	+++	+++	+++	0	0	0	0	+++	+++	0	0

* Growth refers to visible streaks on solid media or turbidity in liquid media.

† 0, no growth, or negative reaction.

‡ +, growth, or positive reaction, the number of plus signs indicating the relative amount of growth or degree of reaction.

§ Nitrite tests used were the sulfanilic acid—alpha-naphthylamine (dimethyl-alpha-naphthylamine) acetate tests, adding 5 drops of each solution and making the reading after about five minutes.

¶ Whenever the nitrite test was negative, the culture was tested for nitrates by the zinc-reduction method recommended by ZoBell (*31*).

a rubber hose to the center of the bottom of the tank and then bubbled up and diffused through the water. It was found difficult to control the rate of flow of gas, because a slight opening or closing of the cylinder valve caused a relatively great change in the rate at which the cylinder lost weight. Breathing the gas arising from the surface of the solution had to be avoided. The solution had no serious effect on the hands. In most of the tests the combs were soaked in fresh water after treatment and the excess water was later shaken from the cells, though this would be impractical on a large scale. Bacteriological examinations were made before and after treatment. Absence of growth on beef-extract agar and presence of slender rods in chains typical of *B. larvae* in carrot-extract or egg-yolk media, and (in the second series) a positive nitrite test in carrot-extract broth, were interpreted as indicating viable spores of *B. larvae*. In the first series, combs were treated for increasing lengths of time from 24 hours, using 4 pounds $3\frac{1}{4}$ ounces of chlorine, to 78 hours, using 10 pounds $8\frac{1}{4}$ ounces of chlorine. In all cases the cultural results were positive for *B. larvae* after as well as before treatment, which indicated that none of the combs of the first batch were sterile. In the second series the concentration of chlorine was increased, the treatments varying from 24 hours, using 10 pounds 3 ounces of chlorine, to 72 hours, using 33 pounds $12\frac{3}{4}$ ounces of chlorine. Inoculations with untreated scales, as well as uninoculated media, served as controls for the cultural tests. Results were interpreted as indicating that treatments of 54 hours, using about 30 pounds of chlorine or less, were not sufficient to sterilize the combs, but that treatments of 60 hours, using about 33 pounds of chlorine or more, did sterilize the combs.

Effects of chlorine treatment on combs.—Careful examination of the treated combs disclosed several disadvantages of the treatment. Although the uncapping of the combs before treatment was done in a very thorough manner, a number of cells were found after treatment to have been overlooked. These cells were irregular cells of three types: (1) cells built at the edges or bottom or corners of the comb where it had not been built out to the frame, the cells pointing inward at right angles to the normal cells, (2) cells capped part way in from the surface of the comb, and (3) conical cells with their sides slanting to a point below the surface of the comb at the intersection of other cells, usually where drone and worker cells came together. Some of these cells still contained honey, and though it tastes of chlorine, might not have been completely sterilized. Such cells are, of course, not an effect of the chlorine treatment, but would be equally dangerous in any disinfecting treatment.

The chlorine-treated combs were extremely brittle and were bleached to a grayish color. If treated combs had to be trucked over rough roads to out-apiaries severe breakage might occur. Cracking of the combs during the treatment was occasionally severe, but usually was absent or negligible. The age and condition of the combs had more to do with the cracking than did the length of treatment or strength of chlorine.

A definite chlorine odor was left in the combs after treatment. No difference was detected between the strength of the odor in combs from which the excess solution had been shaken after treatment and that in

combs in which the excess solution had been left to evaporate. The chlorine odor persisted for at least 11 weeks.

The paint on the hive bodies was affected differently according to the kind and age of the paint. The fresher paints were softened and discolored while certain old paints were washed off completely and others seemed unaffected.

The corrosion of metal parts is perhaps the most serious objection to the effects of the chlorine treatment and is an objection not met with in the other disinfectant treatments. The corrosion of the exposed parts of frame wires was often severe, especially when the combs were not built out to the end bars. Such corrosion is not serious in itself, but may result in severe breakage of the combs when attempting to shake off adhering bees or when heavily weighted with honey. Corrosion of metal frame spacers, nail heads, rabbets, and queen-excluder wires was also noted. In general, the severity of the corrosion was proportionate to the length of the treatment.

Possible disadvantages of the chlorine treatment therefore include brittleness and cracking of the combs, persistence of the chlorine odor, an effect on paint, and especially corrosion of metal parts, particularly the frame wires, sometimes resulting in a serious weakening of the combs.

Field tests with chlorine-treated combs.—In the fall of 1933, 15 package-bee colonies were established. To compare the acceptance of chlorine-treated combs with acceptance of foundation, four types of brood chambers were provided: (1) treated combs only, (2) foundation only, (3) five frames of foundation alternated with five frames of treated combs, and (4) five frames of foundation placed beside five treated combs. The treated combs given each colony included at least one brood comb that had contained a very severe case of the disease. Weekly examinations were made to determine the presence of brood, queen, stores and diseases. The bees preferred foundation to treated comb where both were provided in the same hive, but once brood rearing had started in treated combs it progressed just as rapidly as in new combs. The strongest colony at the end of the season was one with all treated combs. Four of the colonies had trouble with queenlessness. The sugar syrup first stored in the treated combs had a very definite chlorine taste imparted to it. American foulbrood did not appear in any of the colonies, though a few larvae dead of unknown causes were noted in unsealed and sealed cells in colonies with and without treated combs. The colonies were all relatively weak in bees and stores so that no attempt was made to overwinter them.

In the spring of 1934 the 15 colonies were reestablished with package bees, and weekly examinations were made throughout the year. The 1934 season was an extremely poor one due to continued drouth. There was scarcely any spring nectar flow and colonies failed to develop to proper strength for the summer flow. An unusually large amount of trouble was experienced with queenlessness. Only five of the 15 colonies were not queenless at least once during the season. Five of the colonies died of starvation and queenlessness. Two of these were in hives given foundation only, no treated comb being present, and the other three

were in hives given five frames of foundation alternated with treated combs. A sixth colony died of starvation but this was undoubtedly hastened by an earlier period of queenlessness. All colonies provided with treated combs had started rearing brood in them by May 2, except for three queenless colonies which, as soon as they began brood rearing, did so in treated combs. Moreover, of the nine colonies given supers of foundation on July 7, all continued rearing brood in the treated combs throughout the rest of the season. Honey stored in treated combs tasted normal. American foulbrood was not observed in any of the colonies. Sacbrood was observed at least once in 10 of the 15 colonies. In eight of these, only a few cells were found diseased, but in the other two the disease once established was present for the rest of the brood-rearing season. The source of the infection is not definitely known, but sacbrood is of general occurrence in this locality. Other cases of dead brood were observed, but were not typical of any of the known infectious diseases and no spread of these disorders occurred. Colony weights at the end of the season were found to correlate closely with the amount of queenlessness suffered during the season. One colony was completely upset and stoned by practical jokesters the first week in September and was so weakened by the exposure that it was unable to surive the winter. The other eight colonies surviving in the fall were cellar-wintered and consumed about the same amount of stores, averaging $7\frac{3}{8}$ pounds consumed between the first of December and the middle of April.

The eight colonies surviving the winter were examined monthly throughout the 1935 season. One colony was extremely weak when removed from the cellar and may have been queenless. It died within 10 days and the hive was closed. It was restocked with a swarm later in the season. One strong colony swarmed, and was much weakened, but the others were checked in time to prevent swarming. Only one case of queenlessness occurred and was quickly remedied. In all hives provided with treated combs, brood was reared in them at least part of the season. However, there was a decided tendency in the fall to crowd the lower chamber with pollen and to rear brood in the upper stories. This was true in colonies without as well as with treated combs. Slight cases of sacbrood were noted in all but one of the colonies, though all signs of this disease had been cleaned up before the end of brood-rearing. No case of American foulbrood was noted.

From the field tests it was observed that bees accepted foundation more readily than treated combs where both were provided in the same hive. Once accepted, the treated combs offered no hindrance to the development of the colony. A definite chlorine taste was imparted to sugar syrup first stored in treated combs. Sacbrood and brood dead of unknown causes occurred in colonies with and without treated combs, but no recurrence of American foulbrood was noted.

Conclusion.—The chlorine treatment for disinfecting honey combs in the control of American foulbrood, while offering possibilities as a method of sterilizing the combs, has disadvantages in the difficulty of controlling dosage and in its effects on combs, especially its corrosive effect on frame wires. Therefore, it should *not* be recommended to the beekeeping public,

until methods can be devised for obviating its present disadvantages.—9-4-36.

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SECTION OF EXTENSION ENTOMOLOGY

FIGHTING MORMON CRICKETS

ANABRUS SIMPLEX HALD. (ORTHOPTERA, TETTIGONIIDAE)

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We have gone through our fourth year (1935) of the present outbreak of Mormon crickets in Idaho. No warning of the invasion of agricultural or range lands was observed until after enormous bands of "crickets" had reached the irrigation canal at Fort Hall in May 1932. They floated down the canal for miles, occasioning widespread alarm as they reached the irrigated land alive. "Crickets" had, of course, been present in very small numbers in remote areas of the state since the last general outbreak some 18 or 20 years ago. Had funds been available for survey and control, many bands of "crickets" could have been wiped out at small cost as soon as they were observed to be increasing and assuming migratory tendencies.

The known infested area in 1932 probably did not exceed 100,000 acres but, each year since, it has been extended and the increase in the "cricket" population has become more and more alarming. The known infested area now comprises approximately 1,823,000 acres in 23 counties divided as follows:

Public, state or private lands	1,128,000 acres
National forests	476,000 acres
Indian reservations	219,000 acres
Grazing districts (including some lands listed above under public and state)	529,000 acres

Dusting bands of "crickets" with a mixture comprised of 1 part sodium arsenite and 4 parts hydrated lime has been the most effective method of control of those which we have used. Large numbers of the insects can be covered with the poisoned dust at reasonable cost and at a relatively small labor outlay, owing to their behavior in congregating in bands in the late evening or early morning during periods of moderate tempera-

ture, or in mid-day during hot weather. Because of the topography of the land and the types of vegetation on which "crickets" mass, the use of hand dust guns is the most economical and practicable means of applying poisoned dust.

No funds were available when first we were confronted with the need of repelling invading bands but, in the frenzy of excitement prevailing, volunteer labor was abundant and such workers dug approximately 50 miles of trenches in the Fort Hall area in 1932. At times, as many as 300 volunteer workers a day participated. Trenches were not effective, in general, in stopping migrating bands but in a few instances, where soil and weather conditions were favorable, trenches trapped millions of "crickets" before they reached agricultural lands. Trenching, in later work, has been almost entirely abandoned and, where it has been used, it usually has been unsuccessful and time-wasting.

Barrier fences made from 8-inch boards faced with a 4-inch strip of bright tin have been used to some extent. About five miles of such barriers were prepared in the Fort Hall area the first year and 10 miles of it this year in Fremont county. Much of it has not been used. Barriers, in a few instances, have been helpful in checking migrating bands of "crickets" and holding them long enough to dispatch them with sodium arsenite dust or with kerosene or gasoline burners. Barriers are very effective in preventing migrations of "crickets" to agricultural lands if they are erected well in advance of the marching hoards and used as a fence adjacent to or surrounding the land to be protected, but, in general, they have failed when used against individual bands or as an adjunct to dusting, because of the behavior of the insects. The direction of march of "crickets" is not consistent and bands often change their course before reaching a barrier which has been erected in anticipation of their approach. They are likely to miss entirely a barrier erected a half or a quarter of a mile in front of them and the labor involved goes for naught. The noise and confusion incident to erecting a barrier near the front of an advancing band usually serves to change their direction of march. Barriers, as a whole, have proven to be too costly and non-productive of results to justify using or recommending them.

The most effective and economical barrier we have used is a type constructed in irrigation canals to prevent "crickets" from crossing from range to irrigated lands. This type is erected diagonally across the canal, anchored to each bank and constructed of timbers buoyant enough to float and permit workers to cross them. The upstream face of the barrier is faced with smooth tin to prevent the insects from crawling over it. "Crickets" floating down stream are carried against the barrier and toward its down-stream end to the bank of the canal where a Y-shaped trough converges to lead into a flume arising at the water's edge and sloping outward over the top of the bank. The upper end of the flume projects out over a large, smooth-sided hole dug into the ground. "Crickets" reaching the Y-shaped trough gain a footing on the rough bottom, crawl up the incline and drop into the hole where they soon succumb to overcrowding and from suffocation. With one such barrier, a hole approximately 8 feet square filled 6 feet deep with "crickets" so that the trough

had to be extended to lead into another hole dug farther out on the bank. Where the current is fairly swift and canal banks free from brush or overhanging grass, canal barriers almost entirely prevent "crickets" from reaching irrigated lands.

The method of control that uses sodium arsenite dust, has its faults and limitations, but is the best means of control known to date. The effectiveness of the method has been greatly limited by lack of finances and organization personnel. The only area where control work has approached satisfaction is on the Fort Hall Indian Reservation. Control work there, financed through the Indian Service by the U. S. Department of the Interior, has been in progress for four years with the result that that area is the only large one in the state where the "cricket" population definitely is on the decline. No organized, concerted effort has been made to obtain funds by residents of the infested areas as a whole. Farmers are loud in their denunciation of an enigmatic "they" in Washington or in their state government when "crickets" are swarming over their crops, gardens or range lands but they make little effort to fortify themselves against a repetition of the occurrence.

The only funds, outside of the Fort Hall Indian Reservation, which have been available for Mormon cricket control in the state during the four-year period are $6,100 for materials and $14,897.90 for labor provided by the Idaho Emergency Relief Administration, and $8,115.90 appropriated by individual counties. Control work was conducted in 12 counties this year. Exactly 13,162 pounds of sodium arsenite and 53,148 pounds of hydrated lime were used. One hundred thirty-nine dust guns were in operation. A total of 742 men worked 29,991 hours dusting 9729 acres of crop and range land, resulting in an estimated protection of 113,099 acres in crop. It is estimated that 22,023 acres of crops were attacked. The campaign cost $25,327.71 divided as follows: sodium arsenite, $1,645.25; hydrated lime, $664.35; barriers, $2,854.30; labor and transportation, $20,163.81. Although the University of Idaho Extension Division has had no funds for Mormon cricket control, it has had the responsibility for supervision and organization throughout the campaign.

We have cooperated with all agencies interested in Mormon cricket control but entomological supervision and organization have been inadequate to meet the situation. The plan of organization this year was for the extension entomologist to act as state leader and the county agricultural agent to act as county leader of Mormon cricket control. In most counties that were without county agents the commissioners were required to hire a leader to have charge of dusting operations and general county supervision. The entomologist worked with the county leaders and control crews as frequently as possible. Workers paid by the Idaho Emergency Relief Administration applied most of the dust. These worked in crews of four to 30 men. One man in each crew was selected as foreman who carefully scrutinized the work of his crew to assure dust being applied only at the time and place "crickets" were massed, to avoid needless waste, loafing and the use of too much material. Foremen and crew members necessarily were untrained men and had to work for several days before they learned how to apply the dust and how to avoid

injury from sodium arsenite. Men were assigned to crews on an allotment basis which necessitated the changing of crews every two or three days and the training of two or three times the number of workers actually required. Results from relief labor were much more satisfactory this year than formerly, due, mainly, to the fact that foremen exercised their authority to discharge men who were unsatisfactory.

Relief labor was limited to six hours of work per day. The general plan followed was to transport the men from towns in time so that they began dusting operations in the field at 4:30 to 5 a.m. Thus, they worked during the most advantageous period of the day and were back in town by noon. The foremen used the afternoons for mixing dust and for locating bands of "crickets" to facilitate the next morning's work. In some instances, crews worked in the evening or in the middle of the day when "crickets" were bunched and occasionally labor was available so that crews were used both mornings and evenings. Control in areas remote from towns would have been far better had means been available for establishing camps in the centers of infested districts. This was done only in the Fort Hall area where "crickets" were nearly exterminated in an area having a 10-mile radius from the camp site.

Many small, isolated farms were protected by placing dust guns and dusting material with individual farmers. When invading bands reached their farms, they dusted the vanguards, killing many of the "crickets" and turning back the bands. In some areas, however, "cricket" bands were so numerous and extensive that individuals were known to dust for 65 consecutive days in the season. They saved most of their crops by doing so but had little time left for farming. Leafy vegetables, even though not damaged, were unfit for consumption due to contamination by liquid feces of "crickets" which had ingested sodium arsenite.

Cooperation of every interested organization is essential to meet the present emergency. Many of the "crickets" now on agricultural land have migrated there from lands within the National Forests and many of the farms most severely affected were surrounded by forest reserve lands. The Forest Service has taken no part as yet in "cricket" control in this state. The same is true of the Grazing Administration and of other organizations. If successful control is to be attained, it is necessary that there be complete cooperation of all interested organizations and citizens and a unified plan of procedure adhered to. Furthermore, the eight western states affected should have the supervision and coordination that only the Bureau of Entomology and Plant Quarantine is in position to furnish.

What can be accomplished in 1936 is uncertain because funds are not definitely assured. To meet the emergency we feel that it will be necessary to have 119 men working out from towns for 65 days and 253 men working out from 16 established camps for the same period of time. No regular funds are available from the national or the state government and our only hope is that the project we have drawn up with the approval of the State Works Progress Administration will receive official approval without the procrastination that so greatly has limited the effectiveness of relief money which already has been expended for "cricket"

control. In 1935 funds were not made available until "crickets" were approaching maturity. Effective work should begin as soon as the insects hatch.

The eventual success of our Mormon cricket control campaign depends on the following points:

1. Ample funds to purchase supplies and to pay for labor and transportation, made available so materials can be delivered by March 1.
2. Complete cooperation of all interested agencies with adequate federal and state supervision.
3. Control work to start as soon as "crickets" hatch in the spring.
4. Control work in remote areas to be conducted from labor camps established in the infested areas.—7-14-36.

ORGANIZATION OF THE KANSAS ENTOMOLOGY EXTENSION SERVICE

E. G. KELLY, *Kansas State College, Manhattan*

During 1934 and 1935, some agricultural colleges, among them the Kansas State College of Agriculture and Applied Science, have made 20-year plans. The Extension Division of this institution made such a plan in which was included the entomological project.

In this 20-year plan, it is pointed out that the extension entomologist should train farm men, farm women, and 4-H club boys and girls to be leaders in the project. The object in training these leaders is to insure trained individuals in each community who may teach natural history, demonstrate insect control practices and assist the entomologist in making surveys of insect pests. These leaders will also direct control activities in their communities to protect crops, live stock, homes and health from insect pests. It should be pointed out, however, that the county and community organizations with which the extension entomologist has been working during the last 10 or 15 years have gradually improved and are now in very good order. The leaders already have a good start in carrying out the program.

Local leaders assist entomologist.—The trained local leaders are prepared to take part in campaigns for control of insect outbreaks, and what is more important, they are on the watch for the first appearance of the pests and are ready to begin measures for the prevention of serious outbreaks. These men and women make regular surveys of the population of insects to determine the numbers present in the community and whether or not control measures should be applied. Some of the important population surveys made by these leaders have included the grasshoppers, chinch bug, Hessian fly, and garden pests. The leaders send reports of the records made to the extension entomologist for analysis from the counties where these insects ordinarily do damage.

These reports and records made by the members of the experiment station staff are combined and from such summaries are determined the programs to be followed during the coming season.

The farmers in 99 of the 105 counties in the state of Kansas have organized county farm bureaus. These farm bureaus have regular officers consisting of a president, vice president and secretary, and one or more township vice presidents. From among these officers the county agricultural agent, home demonstration agent and extension entomologist together select the county entomology committee. The community local leaders for the entomological project are selected by the county agent, the extension entomologist, the entomology committee, and officers of the county farm bureau. These local leaders represent their respective communities in all their entomology activities, such as in the distribution of poison bait and of creosote oil, and in planning educational events for the year.

The local leaders are prepared for this work by the extension entomologist who meets with them several times each year. Leader-training meetings are usually held during the winter months while the farmers have more time to devote to this work. Later, field trips are made for the purpose of collecting and studying certain pests and demonstrating control methods for them. For example, the time for demonstration of building a creosote–cyanide barrier to prevent chinch bugs migrating into a corn field is usually in May, a few weeks prior to the time when such barriers are needed. The leaders meet at a central place in the county and are informed by the extension entomologist how to construct the barrier, after which a demonstration barrier is built on their own farms for the benefit of their neighbors.

The "summary and achievement" meeting is usually held in the fall. The leaders demonstrate insect control methods at these meetings, make reports of results of control practices and of the number of farmers following these practices in their communities. This is the source of information included in the regular annual reports of the extension entomologist.

Need for subprojects.—The entomology project has been divided into five subprojects for convenience in teaching local leaders and in reporting results. These five subprojects are staple crop insects, horticultural insects, live stock insects, building and lumber insects, and insects of importance to the household and in sanitation.

In former years, when it was necessary to take five or six years to train the leaders in a county, the plan did not permit the extension entomologist to reach the counties as frequently as was desirable. Therefore, the entomology project has recently been reorganized so that the leaders may receive training from the extension entomologist for three successive years, after which they may continue to be project leaders as long as they care to do so.

It was suggested in the 20-year plan that the extension entomologist reach all of the 99 organized counties with leader-training meetings during a 10-year period. The extension division has divided the state into 21 five-county districts for convenience in carrying out an area program.

The extension entomologist has planned for leader-training and insect-control programs during the next 10 years and has selected six five-county districts for 1936–1938, seven for 1939–1941, and eight for 1942–1944. The entomology project will be resumed in the first group of counties in 1945–47. This arrangement will provide for an equal distribution of entomology leadership-training and organization for insect control. It will also make it possible for the entomologist to keep in contact with leaders in the counties whether or not he visits the county during the year.

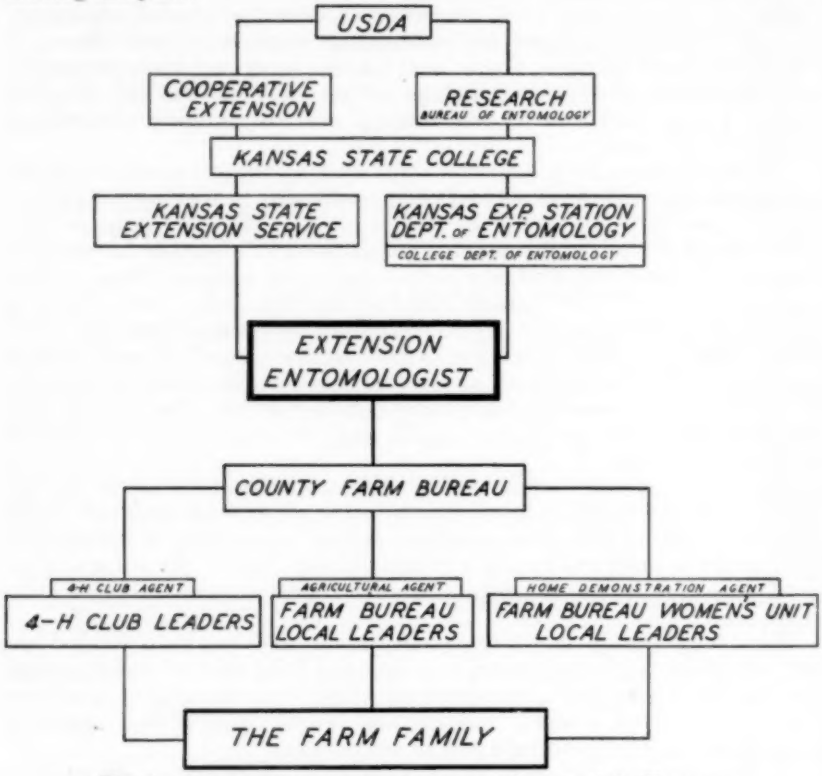

Fig. 1.—Organization of extension entomology work in Kansas.

The cooperative set-up of entomology extension work in Kansas, concerning both the governmental agencies and the community groups through which instruction reaches the farm family, is shown in fig. 1.

Farm women learn entomology.—It was also suggested in the 20-year plan that the extension entomologist train leaders for the women's units of the farm bureau. There are now 28 counties employing full-time home demonstration agents and nearly all the county farm bureaus have women's farm bureau units. The extension entomologist plans to train leaders in these units in 12 or 15 counties each year, but only a one-year

program will be undertaken. These counties will be selected in different districts from those in which the farm bureau program is in operation. The 4-H club leaders will receive their training in conjunction with the farm bureau training meetings, wherever held.

The "wild life conservation" program and 4-H club camps are considered special activities and will be carried on as a part of the regular program in the counties which are organized for the entomology project.

This plan, with a few variations, has been in operation in Kansas for several years, and we have found it to be very satisfactory and workable. It permits coordination with all other agricultural and home economics projects and through the friendly cooperation of the heads of the various departments of the college and experiment station, and fellow workers in extension, the extension entomologist has been enabled to develop and carry out a very successful program.—9-4-36.

SOME THOUGHTS ON TEACHING ENTOMOLOGY TO ADULTS

A. B. GRAHAM, *U. S. Department of Agriculture, Extension Service*

Teaching is one of those peculiar verbs which takes two objects—one the person, and the other, the thing. We teach the person soil conservation; we teach the student insect control. Perhaps the easier part to perform is in the field of subject matter. We can teach sprays, insects, life histories, machinery, etc., as subjects probably a little easier and with much more definiteness than we can teach persons of varying mental and temperamental characteristics. But, after all, the person is the one we are after. What does extension signify, if we are not doing something to cause the person to become interested in the subject matter? What use is he to make of it? Why should he use it? How does one appeal to an adult?

Individual characteristics.—Let us look over some characteristics of the individual on whom we have to work. He desires to gain certain facts for, let us say, economic purposes, but why economic? That simply means that he is to use what he has saved for some satisfaction for himself. That brings us face to face with two other characteristics—satisfactions which he desires and annoyances which he shuns. If he lacks money to buy spray mixtures that is annoyance. A credit plan must be devised. If he is ignorant of how to prepare a spray mixture that is also an annoyance. He must be taught how to substitute a satisfaction for an annoyance. The individual also likes to be recognized as somebody worth while. He has a pride in his own accomplishments so one appeals to that—that he put fine fruit on the market or that his vegetables or animals excel others because of what he may do in following instructions. These are satisfactions that are produced through appeals to his ego.

He likes to know that his curiosity is appealed to. Curiosity is as much of a human characteristic as an appetite is. We appeal to him to put on a demonstration which has been proved by research; we want to recog-

nize him as an individual and also for the purpose of helping him to teach others in his community.

The fact is that the possession of knowledge does not necessarily throw people into action. And so, our information and knowledge which we endeavor to transmit to him, or to develop a desire in him for acquiring, comes to naught if we do not appeal to his inherent characteristics—pride, curiosity, ingenuity, creativeness, desire to help others, and so on, in our efforts to build up an interest within him to acquire, to want, to hunger for the information and knowledge which we have.

The use of the word "method" does not always imply a teaching method; it may be a method of organizing people or subject matter. "Method" may mean how to organize and to carry on a survey or piece of research work. Thus, if we mean teaching when we say method, then why not say *methods of teaching*?

Avenues of approach.—Now there are only about three outstanding methods of teaching: first, the oral; second, written; and a third, the objective method. It is well to have a clear understanding of each method and the time and place in which to use it, for probably we shall have to use all of them and our desire is to use them effectively.

Let us consider the outstanding avenues of approach to our minds. We get most of our messages through sight. That characteristic is called eye-mindedness. We receive a great many messages through the ear, and that is called ear-mindedness. We receive many other messages through the tactile senses and this is commonly called manual-mindedness because we handle things with our hands, but it may be any sense of touch—the learner jumps into a job and helps to do it. This performance is always very important because through participation we learn the details which otherwise would be learned with great difficulty. Everybody is eye-minded, ear-minded, and manual-minded. Some are minded more dominantly one way than another. The "tools" for teaching must be used to reach the individual through all of the entrances to his mind.

Teaching tools.—Those things which we use in the teaching process are but the tools, or the implements of teaching. One would not say that a chisel is carpentering, or that an anvil is blacksmithing. The whole of what the carpenter has to do is carpentering, the whole of what the blacksmith has to do is blacksmithing, regardless of what tools are used. If the wood worker has a soft-grained piece of wood to dress, he knows from experience what kind of tool to pick up from his chest. The blacksmith selects the tool with reference to the material he has to work on. So it is with our work; if we are teaching, we must think of temperaments or the timber we have to work on, what their aspirations are, what degree of curiosity they have, whether they are interested or not, and if not interested, how we can cause them to become interested. We look into our chest of teaching tools and "pick up" a lecture for those who are dominantly ear-minded. They can hear what we say if we choose the kind of language which they can understand and if we have organized it to proceed by easy steps from where the learner is to the new things which he is supposed to learn. Even then we may find that we are a little mistaken in the timber we are working on, for in the presentation to the

ear-minded we must not forget that they must have the constructive power of the imagination or they cannot build up what is being given to them through their ears. This constructive, creative imagination is very essential but as a rule it is not very strong in most people. Most people have a representative imagination so we must look into our chest and pick up a demonstration or a film, a diagram or photograph, or something that appeals to the eye because their *imagination is not so largely constructive.* And so we give them what are called object lessons or demonstrations. Since a large percentage of people have a representative imagination, the demonstration or object lesson has to be used as a tool in teaching. This is for the eye-minded rather than the ear-minded, but both methods make a fine combination, because we reach the ear and check up on what the mind has built by presenting something for the eye. Then suppose we request the learners to get into the game and do spraying—that is, participate in it. They handle material in preparing mixtures, or in adjusting machinery. This tool, participation, picked up from our chest of teaching materials, helps to satisfy those who are manual-minded because they participate in the doing. When one uses all three methods to get into the mind of the learner through these three avenues, the learner is helped to change his attitude and acts, which are evidences of his having learned.—9-14-36.

CHALK TALKS IN EXTENSION ENTOMOLOGY

R. R. REPPERT, *Texas Extension Service, College Station*

The chalk talk is only one of the numerous devices we use in putting over our entomological work in Texas. The subject, which deals with creatures so small as to escape the notice generally of all but the more observant, is of a nature approaching the abstract; hence it is desirable in some way to arouse a special interest. Visual means find a ready adaptation here. To use a common expression, lessons presented by word of mouth only, may go "In one ear and out the other." Things presented to the eye, however, are more likely to leave a permanent impression.

While this method of presentation has a special appeal to juveniles or club boys and girls, it is by no means not adapted to older persons, who, time and again after such a lecture on insects and their control, have assured us that they secured thereby a much clearer understanding of the subject than they had formerly obtained through mere spoken messages.

Devices to attract attention useful at start.—In our work we are not averse, if the opportunity offers, especially before juveniles, to going somewhat afield and using some little simple trick or magical effect, or including some drawing of a merely entertaining nature, to arouse or sustain interest at critical points. Too generous use of such, of course, would defeat the educational purpose of an insect talk, and one must use judgment here. We realize that some instructors might question our

method of visual instruction in their entirety. One of our co-workers in Texas (not an entomologist, by the way) has accused us on more than one occasion of "making monkeys of ourselves."

A drawing which we commonly use early in our lecture, and usually the first of the series, is the sleepy man. This allows us the opportunity to refer to the several hundred thousand species of insects, and why an insect talk ordinarily is a dry subject. By rounding out the eyes, we quickly bring the man fully awake, the final effect being to put the audience in an anticipatory and attentive mood.

If it appears advisable because the audience seems restless, we sometimes use the three well-known lines, namely the straight, the broken, and the curved, representing the soldier just going into a door followed by his faithful dog.

An upside down picture always adds interest, and can be made amusing, though to the present time we have not devised one particularly relevant to the subject of insects. One which we often use is the strange "Snoffelgee" bird, of queer form and habits, the drawing of which rapidly progresses to the stage where it can be turned over and then appears as a Hottentot. In drawing some difficult subject, it is safest to make its habitat some little-known foreign land, so that the audience of their own knowledge may not become too crticial. With recent publicity given the Ethiopian conflict, and the newspaper illustrations accompanying, this "Snoffelgee–Hottentot" picture bids fair to become dangerous unless we can add some sort of headdress and nose and earrings.

The two types of insects and their control.—Having created an interest and a feeling of fellowship by these few pictures, which may be as varied as one wishes, we undertake to present the subject of insect control in general by drawing one after another, the heads of typical chewing and sucking insects. The head of the grasshopper is drawn, showing its antennae, eyes and other features, and lastly its mouthparts. A blade of grass or corn is pictured then in the process of being devoured. This gives opportunity to show next how a covering of some arsenical applied either as a spray or dust will control an insect that actually devours the leaf substance. The names of the arsenical compounds may be written down on a corner of the sheet.

Immediately following this drawing is the side view of a plant louse, the beak being drawn last, and then the section of a leaf drawn about this to show how it sucks the sap and why a covering of poison on the leaf will not kill this type.

Before suggesting the actual materials used in controlling the sucking type of insects, we use another sheet to draw the side view of an insect, bringing out some of the points of similarity between people and insects. The final few strokes develop the breathing pores, and then it is shown how some materials applied as sprays or dusts will control some pests by closing the breathing pores or by irritating the insect counterparts of human lungs.

How cultural measures may be used in insect control.—Cultural measures in insect control are illustrated by a drawing of the boll weevil, the most common example of destructive insects in Texas. This is shown

humanized (and with the entomological error of only four legs) wearing a hat, smoking a pipe, and reading a circular directing where the best winter quarters may be found. This gives us the opportunity of advising an early clean-up of crop residues for the control not only of the boll weevil but of many other destructive insect pests and of special value in the control of garden insects.

We usually follow this humanized drawing of the boll weevil studying his guide to winter quarters with another, showing him, at the approach of cold weather, wearing a cap and burdened with a traveling bag and some excess baggage tied in a bundle slung over the end of a pole, trudging along a road and breaking out in smiles as he comes up to a signboard directing him to "Jones Fence Corner" grown up with weeds and banked with trash, a short distance farther on. This gives us opportunity to urge the judicious disposition of such winter quarters for insect pests.

Other sheets are used to present in order the drawing of a dancing match, helpful in the disposal of trash under conditions where its destruction thereby will not be particularly harmful in the organic matter it removes; of a lady-bird beetle, and of a skunk, each representing its class in the destruction of harmful insects.

Importance of birds in reducing insect numbers.—In drawing our last picture, we take rather particular pains, partly because of the impression a last picture leaves, and partly because of the importance of its subject in reducing insect damage. This is a bird, and during its drawing we stress the good work this group does, mention the one or two exceptions, dwell upon their unjustified slaughter and diminishing numbers, and make a plea for their protection.

Chalk-talk method invariably fixes interest.—We have outlined our chalk talk in the general subject of insects. It usually takes us about an hour to give this, and unless there is a draw to play off in some school basketball tournament, we are usually successful in holding the attention of juveniles, as well as older people. In fact, on occasion when we have taken the regular club hour in school to present this talk, we have been implored by the boys and girls to continue, and that their interest might possibly be due to a quiz in algebra or history the next hour is disproved by the fact that we have sometimes been so implored at the opening of recess, or at the noon hour.

We have used the chalk talk with good effect in relation to specific insects and their control, but these present such a broad subject that no further mention need be made of it here.

Materials for a chalk talk.—In making our chalk talks we use the soft lecturer's crayon 3 inches long, and an inch square, obtainable at book stores in the larger cities. Coarse newspaper stock may be used, but should be rough. We use a special heavy Manila paper of rough surface, 32 by 42 inches. As each drawing is completed it is torn off and cast aside. There is no difficulty in disposing of them at the close of the lecture; in fact we have often wondered if we couldn't add to our income by collecting a nickel each for these. Teachers sometimes keep them for illustrating future lessons.

Chalk talking in emergencies.—Often at club meetings in schools

where we have not anticipated a part in the program, we use the blackboard with white chalk. This is not as well adapted to the work as black on white, however, and of course upside down pictures are impossible. Formerly we depended upon a wall against which to tack our sheets, but a desirable wall was often not available, and we have made a portable and collapsible board to carry with us.

One must be able to "chalk" and talk at the same time.—It is of course essential that one talk all the time one is drawing. This is not easy at first, for one must give close attention to his drawing. In time, however, especially with repetition, one finds no difficulty in drawing and talking at the same time. It adds greatly to the value of the talk to bring out all possible facts that are interesting, and if one can be properly humorous, all the better. With repetition one soon learns to take advantage of humorous experiences; in fact one will learn how to create humorous situations occasionally. In chalk talking, one should not worry about detail. The drawings should be made with the fewest possible lines, and in general should be heavy. A feeling of dissatisfaction with one's drawings or their progress is apt to be experienced. One should remember, however, that distance brings out the good points of a drawing and serves to tone down the defects.

This in brief is one method we employ in presenting the subject of insect control. It is satisfying to us, and interesting as well as instructive to our people, both young and old.—9-14-36.

CRICKET CONTROL IN WASHINGTON

IRVIN W. BALES, *State College of Washington, Pullman*

Eastern Washington with its interspersed cultivated and range lands furnishes an optimum breeding ground for the Mormon and Coulee crickets. In the spring of 1934 these insects became a menace and the writer was detailed, by the Agricultural Extension Service, State College of Washington, to demonstrate and supervise control measures.

Several outbreaks of these insects have occurred in this state. In 1877 this pest was reported in eastern Washington near Colfax. The next record which we have of a serious outbreak of this insect was in 1933 when it became very numerous in Franklin county. Although Mormon crickets were noticed in Franklin county at least four or five years prior to 1933, they were not present in threatening numbers until the last three seasons. At the close of the 1935 season the infestation had spread to an area of approximately 195,680 acres of cultivated and range lands. Of the 195,680 acres now infested, 48,640 acres are crop land. The larger portion is wheat land although extensive truck gardening is practiced in this area. The crickets did not reach the truck-gardening area until 1935.

A brief survey of the Franklin county agricultural situation will show the necessity for cricket control. More than 77.5 per cent of the land in Franklin county is now farmed. A brief quotation taken from the 1935 Franklin county census (1934 crop) shows the following figures.

> Wheat totalled 87,582 acres and yielded 1,272,522 bushels. Other cereals harvested yielded 3491 bushels. The potato yield totalled 53,928 bushels. Hay yielded 13,887 tons. Livestock totalled 67,473.

These figures do not include the extensive truck gardens and small fruit in this county.

Potato foliage, grape and other small-fruit foliage as well as grains are a delicacy for this insect. As an example of the voracious nature of these insects we need only cite one instance where a band of crickets extending over a front of two miles or more migrated into a 400-acre field of wheat. Before the crickets could be checked, 100 acres had been infested. Although the crickets were in the field only three or four days harvest records show that two-thirds of the crop on this area was destroyed.

The actual amount of wheat destroyed in Franklin county in 1935 is unknown. However, conservative estimates of losses of wheat, berries, grapes and truck crops which were destroyed were placed at approximately $5600. Had control measures not been practiced damages would have ranged from 50 to 100 per cent on several hundred acres of cereal and truck-crop lands. The total cost of the control project in Franklin county in 1935 was $5398.90.

The Coulee cricket, *Peranabrus scabricollis*, a very close relative of the Mormon cricket, was present in damaging numbers in Grant county in 1899 and again in 1915 and 1916. The Coulee cricket has caused serious losses in Chelan county during the last two seasons. This insect has the same host plants as the Mormon cricket—almost any green vegetation. Approximately 4100 acres of land are infested in Chelan county. Figures are not available on the total amount of damage to cultivated crops caused by the Coulee cricket this year. Some grain was totally destroyed. A second crop was planted on the denuded field and this crop was successfully protected by dusting with sodium arsenite. Control operations in Chelan county this season cost $1164.27.

Control measures for these two pests are the same. Since Mormon and Coulee crickets are wingless insects, several types of barriers are used successfully to keep them within certain bounds. The use of metal barriers, 12 to 18 inches high, with a 2 to 3-inch flange at the top to prevent the crickets from going over the wall, is very effective in stopping the progress of the bands of crickets. Although the barriers are effective, this is a very expensive control measure. Trenches 18 to 24 inches deep with one straight bank have proven to be an effective barrier in Franiklin county. This type of barrier is effective only in localities that have a sandy soil, on which account the crickets are unable to obtain a firm hold and ascend the bank. Approximately 30 miles of such trenches were constructed in Franklin county this past season at a cost of between four and five dollars per mile.

Burning native vegetation has been practiced in some cases to prevent crickets from migrating into cultivated fields. This is not a desirable procedure as the percentage of cricket kill does not warrant the loss in pasture destruction.

Arsenical baits have been used with varying degrees of success. Al-

though the crickets have a very greedy appetite they were very erratic in their feeding habits. A bait composed of the following ingredients has been used.

Bran	120 lbs.
Sawdust	25 lbs. (approximate)
Sodium arsenite	7 qts.
Molasses	2 gal.
Amyl acetate	5 oz.
Salt	8 lbs.

Chemical analysis of the above bait shows that six to nine flakes (.082 milligrams of arsenic) of the poisoned bran or sawdust constitute a lethal dosage.

White sodium arsenite dust with hydrated lime as a carrier is being used extensively for cricket control at the present time. The mixture is 1 part white sodium arsenite and 4 parts hydrated lime by weight. It may be possible to increase the amount of lime. An equal volume (2 pounds) of diatomaceous earth has been substituted for the lime and the results have been encouraging. Better dispersal with quicker kill is obtained than is the case where lime is used. In experimental cages 100 per cent kill has been obtained with 2 pounds of white sodium arsenite and 5 pounds of diatomaceous earth. The rapidity with which the poison kills is greatly increased with temperatures above 90° F. There is a possibility that further experiments with dusts will be carried on next season.

To date no insect enemies of the cricket have been observed in Washington, although in other states two hymenopterous insects are known to attack the crickets and their eggs.—7-14-36.

EFFECTIVE GRASSHOPPER CONTROL BY FARM OPERATORS

FRED D. BUTCHER, *North Dakota Agricultural College, Fargo*

Grasshopper control has occupied much time and attention of North Dakota farm operators during the past five seasons. Previous to 1931 grasshoppers had not been troublesome since the outbreak of 1917–23. These are the most recent of several crop-destroying outbreaks of grasshoppers, which have occurred during the agricultural development of the state.

North Dakota's latest grasshopper infestation presented many farm operators with a new problem with which they had had no experience and which they did not know how to handle. All of them, apparently, had heard stories of the complete crop destruction caused by grasshoppers during the early history of the territory. Also, control work in the 1917–23 infestation was started late in many counties and crop destruction occurred simply because it was impossible to secure bait materials in sufficient quantities in time to destroy the hoppers before the crops were gone. This experience left an attitude of doubt concerning effective control. Those farmers attending meetings early during the 1931–35 out-

break were skeptical, puzzled and discouraged, but anxious to save their crops. Specialists of the Extension Service found it necessary to present suggestions for organized control carefully and complete as to details. These meetings were first conducted in 1931 and have been continued to date.

For the seasons 1931, 1932 and 1933 it was necessary to organize control under a state law which permits the use of county funds raised by taxation. Local responsibility had to be assumed for organizing control work, and it is interesting to note that the number of counties in which control campaigns were conducted increased with the spread and increase of the infestation. In 1931 control campaigns were conducted in five counties. In 1932 the number increased to 17 and in 1933 it was 26. The control work in these years was under way in most counties in good season and crop protection was generally successful. Crop losses were extensive only in areas where no control was attempted or where it was inefficiently conducted.

Farm operators gained both experience and confidence in grasshopper control during these three years. They noted how closely the infestation which developed was in accord with the infestation predicted from survey observations. They saw thousands of grasshoppers which had been killed by the bait they had scattered and they learned to locate egg beds where young hoppers could be killed before they destroyed crops.

As farm operators were getting this experience, the Extension Service was perfecting its educational activities and its outline of control campaign organizations. The fact that the surveys were accurate so strengthened the work of the Extension Service that it was possible to go ahead in any area with definite knowledge about the severity of the infestation which would need to be controlled. I am convinced that survey information, such as has been available in North Dakota each year since 1931, is a requirement if the Extension Service is going to be able to do effective work in organizing grasshopper control campaigns early enough to prevent grasshoppers from destroying crops.

The high point of control work in North Dakota occurred in 1934. Federal funds being available to supply control materials made it easier to organize the campaigns, and the experiences of the previous years had established confidence among farm operators concerning the possible success of control effort. In spite of the serious drouth, control work continued and reduced the infestation in every county in the state. These results were possible on account of the confidence of farm operators and the carefully organized campaigns in each of the 53 counties of the state. The control work in 1934 has succeeded in establishing the value of control effort. This value is realized by county governing boards as well as farmers.

Less grasshopper-control effort was expended by North Dakota farm operators in 1935 than in 1934. The infestations were lighter, much later in developing, and did not cause crop destruction as they had in previous season. Little educational or demonstrational work was done by the extension organization in 1935. Failure to hold meetings to discuss grasshopper control made it possible for farm operators to conclude that those

best informed about the grasshopper infestations were not anticipating trouble in handling the situation. To date, this is the weak place in the development of grasshopper-control programs in North Dakota. Our experience this season will be valuable and be a guide in future educational activities and should strengthen them. Farm operators' present expressions of concern about the 1936 infestation show an increasing spread of the realization that grasshopper control is more than a one-season task.

North Dakota has learned much about grasshopper control work since 1931. The lessons will be valuable for future control activities, which should be directed to preventing the development of crop-destroying infestations. To realize this goal it will be necessary to plan future work carefully and remember the lessons of the past seasons.

Farm operators are interested in control: first, to enable them to escape crop losses; and second, to prevent infestations developing the following year. This latter approach is a new one to them and will have to be kept before them by educational work. Well-informed farmers understand the necessity of control to prevent outbreaks, but not all farmers are well enough informed. This situation must not be overlooked in future work.

Inasmuch as natural enemies or unfavorable climatic conditions will at times practically control an infestation of grasshoppers, some farm operators are ever hopeful that they will do so again. Future educational work must point out the fact that these natural agencies are not subject to man's directions, nor can their effect on an infestation be predicted. Educational work must also point out the insurance feature of preparations for control and the absolute necessity of cleaning up small infestations before they have an opportunity to build up under favorable conditions. If this phase is neglected, we may expect to have future outbreaks.

Most farm operators in North Dakota have come to depend on surveys to determine areas where infestations are expected. Plans of the Extension Service on future grasshopper-control work depend on these surveys by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture. The information supplied by them is the foundation upon which educational progress and successful control campaigns are built. It has been gratifying to watch the development of infestations so nearly parallel to those predicted from the survey.

Farm operators need accurate information in order for them to handle a grasshopper infestation satisfactorily. If the extension organization will supply the information and outline the procedure of control effort, grasshopper infestations can be kept low and crop losses prevented. It will be necessary for the Extension Service to be advised of the changing situation from year to year and to continue its series of informational meetings. Thus farm operators can know what effort will be necessary and can control infestations before they become severe.

The practice of conducting annual surveys to determine infestations developing for the coming season will, in time, make it possible to isolate areas of most frequent development of outbreaks and special attention to these areas will keep incipient infestations down or under control. In these areas grasshopper control will become a routine farm operation.

With the continuance of the procedure discussed, North Dakota farm operators can look forward to the time when losses caused by grasshoppers will be negligible.—4-13-36.

THE EXTENSION SERVICE AND INSECT CONTROL

M. P. JONES, *U. S. Department of Agriculture, Extension Service*

To picture adequately the work of extension entomologists, the writer deems it advisable to give the set-up of the federal Extension Service. Figure 1 is a chart of this organization.

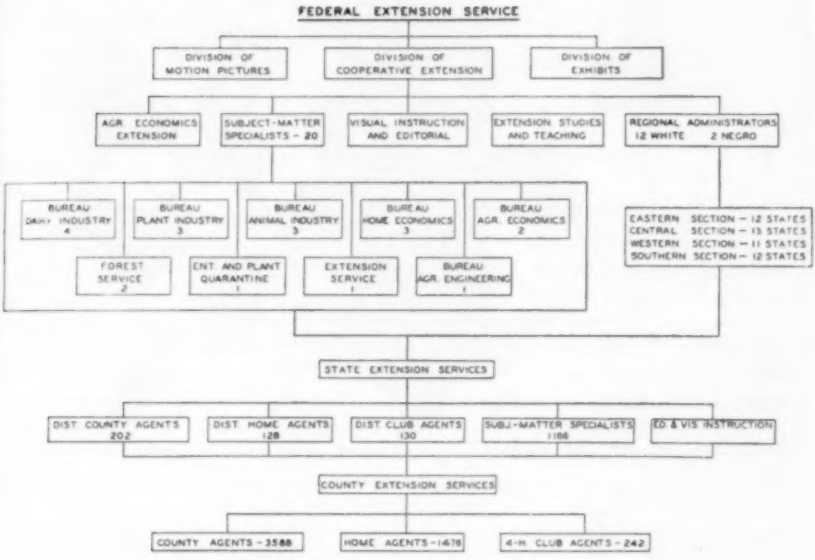
FEDERAL EXTENSION SERVICE
DIVISION OF MOTION PICTURES
DIVISION OF COOPERATIVE EXTENSION
DIVISION OF EXHIBITS
AGR. ECONOMICS EXTENSION
SUBJECT-MATTER SPECIALISTS - 20
VISUAL INSTRUCTION AND EDITORIAL
EXTENSION STUDIES AND TEACHING
REGIONAL ADMINISTRATORS 12 WHITE 2 NEGRO
BUREAU DAIRY INDUSTRY 4
BUREAU PLANT INDUSTRY 3
BUREAU ANIMAL INDUSTRY 3
BUREAU HOME ECONOMICS 3
BUREAU AGR. ECONOMICS 2
FOREST SERVICE 2
ENT. AND PLANT QUARANTINE 1
EXTENSION SERVICE 1
BUREAU AGR. ENGINEERING 1
EASTERN SECTION - 12 STATES
CENTRAL SECTION - 13 STATES
WESTERN SECTION - 11 STATES
SOUTHERN SECTION - 12 STATES
STATE EXTENSION SERVICES
DIST. COUNTY AGENTS 202
DIST. HOME AGENTS 128
DIST. CLUB AGENTS 130
SUBJ.-MATTER SPECIALISTS 1166
ED. & VIS. INSTRUCTION
COUNTY EXTENSION SERVICES
COUNTY AGENTS - 3588
HOME AGENTS - 1478
4-H CLUB AGENTS - 242

Fig. 1.—Organization of the federal Extension Service.

It will be noted that for administrative purposes the United States is divided into four sections. Each section is administered by one person in charge, who has one to three assistants. The work is divided into county agent, home demonstration, and 4-H club work. The regional sections also have an active part in coordinating the projects of the subject-matter specialists within the agricultural college. There is one person in charge of the subject-matter specialists of the U. S. Department of Agriculture, represented by 20 men and women assigned by the different bureaus indicated by the numbers in the brackets. The figures in other brackets indicate the number of people in the United States and its possessions serving under their respective headings.

There are 3077 counties in the United States and its possessions, most of which have county agents. There are 5306 county, home, and club

agents who are making contacts with the farmers on the six million farms. What could afford a more ideal medium than the Extension organization through which to convey the findings of research into the hands of the farmers?

About half the states have extension entomologists. The map, fig. 2, shows the distribution of these. Pennsylvania heads the list with four full-time extension entomologists, and one full-time beekeeping specialist. Ten states have beekeeping specialists. In other states the extension work in beekeeping is done by the regular extension entomologist.

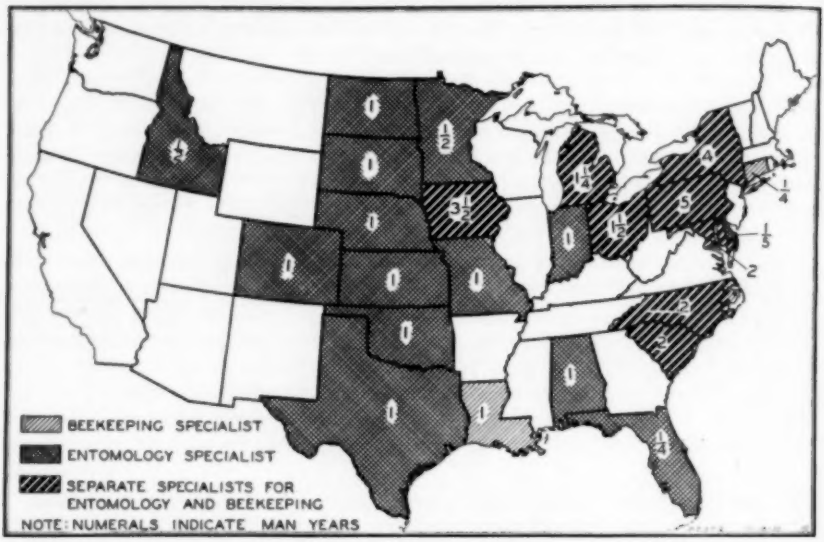

Fig. 2.—States receiving federal funds for extension entomology and beekeeping, Nov. 18, 1935.

Data for 1935 are not available, and in order to give an idea of the amount of insect control work being done by county agents, the summary of the 1934 reports has been used. About 1,484,510 insect-control practices were adopted by farmers, as a result of the efforts of the Extension Service. If these are broken down according to the work of the divisions in the Bureau of Entomology and Plant Quarantine, the projects would be divided as follows:

488,821	Truck Crop and Garden Insects
464,685	Cereal and Forage Insects
351,399	Insects Affecting Man and Animals
102,322	Fruit Insects
63,177	Cotton Insects
14,106	Bee Culture
1,484,510	Total Projects

These figures, while not absolutely correct, give a fair picture of the insect problems confronted by the farmers. Figures are available for proj-

ects on specific crops and domestic animals, but time will not permit enumerating these. These data take into account only the extension projects and no reference is made to forest insects, Mexican fruit fly, pink boll worm, and certain other pests handled by the regulatory forces.

About half of the states do not have an extension entomologist. The extension problem in entomology in these states is that of developing a definite program instead of meeting sporadic emergencies or of doing personal service work.—9-8-36.

SECTION OF PLANT QUARANTINE AND INSPECTION

PROGRESSIVE INTENSIFICATION OF UNCONTROLLED PLANT-DISEASE OUTBREAKS[1]

S. B. FRACKER, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

The classes of plant-disease outbreaks to which your attention is invited this morning are those which because of their extensive nature and widespread economic importance are matters of general public concern. This section of the Association consists of the officers who are responsible to the public for the field control of such outbreaks. The paper does not propose to contribute further details to the knowledge of the individual life story of one or several fungi, nor to assemble and summarize the detailed picture thus obtained. Its object is rather to open up a somewhat different line of approach and to see whether we can discover ways in which the development of plant-disease outbreaks follow general laws of widespread application in diverse fields and, further, to suggest three new or somewhat unused tools for the study of fungus and insect populations. Observations of this type may help us to understand the meaning of past events and the probable future course of outbreaks of this kind. If so, they may make it possible to plan more carefully and successfully in the future than in the past.

Rate of increase of infection.—In 1838 Verhulst (7) pointed out that human populations, although perhaps biologically *capable* of increasing continuously in a geometrical ratio, did not, in fact, follow that course. He found instead that the population increased faster and faster until a certain stage was reached and then grew more and more slowly until it seemed to approach a point beyond which a greater number of people could not be supported. Verhulst called the graph of the equation he worked out to represent such growth a "logistic" curve. The shapes of such curves for two different rates of growth are shown in fig. 1.

[1] Acknowledgment is made of suggestions and assistance from numerous employees of the Bureau of Entomology and Plant Quarantine, including E. C. Filler, W. O. Frost, Edwin E. Honey, H. N. Putnam, K. K. Stimson, and S. N. Wyckoff, as well as helpful comments from the Division of Forest Pathology of the Bureau of Plant Industry.

Pearl & Reed (*5*), without knowing of Verhulst's work, reached the same conclusion independently in 1920. They found that in the case of human population the lower limit from which the development starts was not necessarily zero and that the upper limit to which it was tending could be computed by a method of repeated approximation. They reported that after one had established these upper and lower limits, the logistic curve provided an adequate way of describing population changes in the groups with which they were working. It was based on this rela-

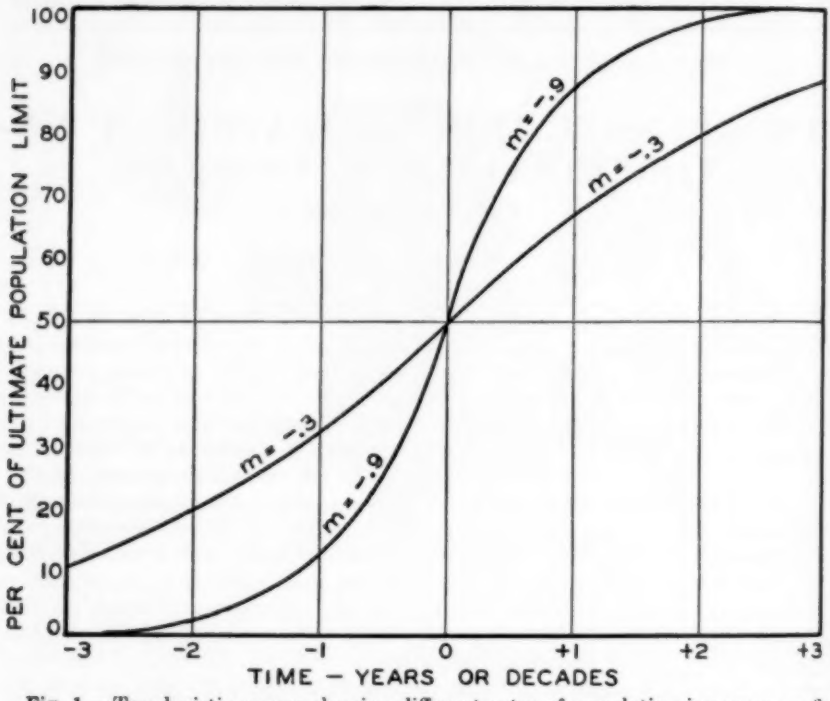

Fig. 1.—Two logistic curves showing different rates of population increases, −.3 and −.9 respectively, the time being indicated a "−" or "+" representing periods before or after the date that 50 per cent of the final population was reached.

tionship that Pearl and Reed first estimated that the population of the United States cannot be expected to increase beyond 198 million, an estimate which has since been materially lowered.

Let us now consider how these studies in human population may prove useful in arriving at an understanding of the nature and development of plant-disease outbreaks. Last winter the writer became interested in following the progressive intensification of the white pine blister rust (caused by the fungus *Cronartium ribicola*) in those sections of the United States where this disease has been established for a number of years, particularly in New England and in the far west. The blister rust, on account of the manner in which it attacks the tree, provides a particularly con-

venient method of working out the annual increase in infection, especially in the regions where it is attacking the northern white pine, *Pinus strobus*. Like a number of other conifers, the main stem and each of the branches of this species produce a whorl of twigs at each node. One internode is normally produced each season. The needles in this species are usually retained for only two or three years. Thus the needles in any one season are present mainly only on the terminal stem and branch growth and on the preceding internode. White pine blister rust infection

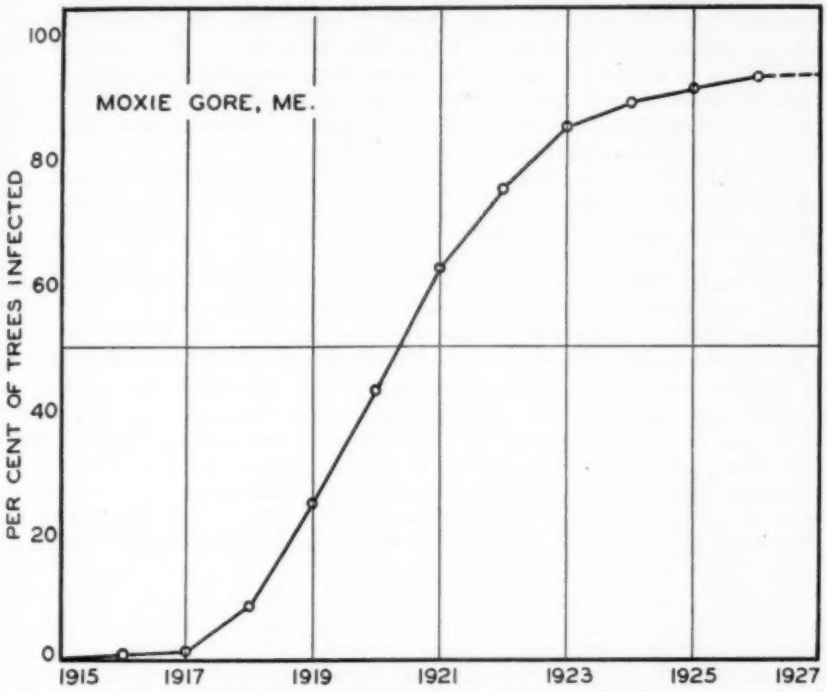

Fig. 2.—Course of blister rust infection at Moxie Gore, Me. 100 per cent = 875 trees, total number in plot studied. Examined in 1930.

occurs through the needles; the hyphae of the fungus grow down through the needle into the twig and a canker develops on the twig at that point. Such three-year-old needles as are present in *Pinus strobus* normally drop too early in the fall to permit infection to enter through them. Consequently infection occurring in 1935, for example, produces a canker on the internode formed in either 1935 or 1934. One-year-old needles appear to be more susceptible than those of the current season, but this is balanced somewhat by the larger number present on the current season's growth. Many years after infection occurs, therefore, it is possible to date that infection with considerable accuracy by determining the age of the internode on which the canker was started.

There are available for the study of the history of infection the results of canker surveys on numerous plots in the northeastern states in which the past record of blister rust infection is shown tree by tree, and canker by canker. As the blister rust is of recent origin in the United States, only a few of these plots give a full record of the progress of infection, starting with a healthy stand, going through the preliminary stages of becoming firmly established, reaching that stage when the spread is so rapid that it sometimes is designated as the "explosion," increasing more slowly as the number of remaining healthy trees becomes less and less, but proceeding inevitably toward the nearly complete infection of the stand. Nearly all of the detailed records relate to trees under 20 feet in height; in only a few cases have the field men counted the cankers on relatively mature trees, since canker determination on such trees is difficult and unsatisfactory and since it is usually impracticable to climb a considerable number of large pines.

One of the most complete studies of this entire course of development was carried out by Mr. W. O. Frost in 1930 in a plantation in the town of Moxie Gore, some 40 miles north of Skowhegan, Me. The *Ribes* had not been eradicated from this stand and the disease was thus able to run its course under natural conditions. The trees were planted in 1916 and are not known to have been infected at the time of planting.

The course of infection in this stand is shown in fig. 2. The general region was already infected at that time and the *Ribes* in and near the plantation were subject to outside sources of infection. The period of preliminary establishment of infection in the planting was thus very short and a period of rapid increase followed unusually promptly. One tree was found to have an infection that began on the 1916 wood, but infection began on the 1917 internodes of 14 more trees. In 1918 there were 66 additional infected trees, 143 more in 1919, 153 additional in 1920, and the maximum number of newly infected trees 170, came in 1921. This was followed by 117, 79, 31, 22, 10, 4 and 2, in 1922 to 1928, respectively, so that by the time the study was made in 1930, 812 of the 875 trees (92.8 per cent) bore blister rust cankers. Six of these, however, were on 1927 and 1928 wood, and as cankers less than three or four years old are so inconspicuous that many are overlooked, the records for 1926 are the latest that could be considered complete. The dates given here for infection are those of the internode on which the canker occurred and may thus differ by about one year from that on which infection actually took place.

The similarity of the curve in fig. 2 to that of the development of human populations is unmistakable. The lower limit from which increase started is zero and the upper limit is 100 per cent of all the susceptible trees within reach of living blister rust spores.

Now the interesting feature of the Verhulst population curve is that it follows the same *type* of course whether the *rate* of increase is slow or rapid, whether the organism finds an abundant food supply and can multiply as rapidly as its biological powers permit, or whether it is in a barren and desolate environment and can strengthen its hold only by the smallest of degrees. Accordingly, when we examine the reports of the

blister rust infection in different sections, we find sometimes a slow and gradual ascent and at other times an increase so rapid that it can be described only as violent and disastrous.

In fig. 3 there are shown on the upper unbroken line the consolidated results of the studies of 16 different unprotected plots containing 3998 trees in six New Hampshire counties. Of the pines examined in these plots, 2300, or 57.5 per cent, were showing visible cankers at the time the trees were examined in 1934. The small circular spots represent the ac-

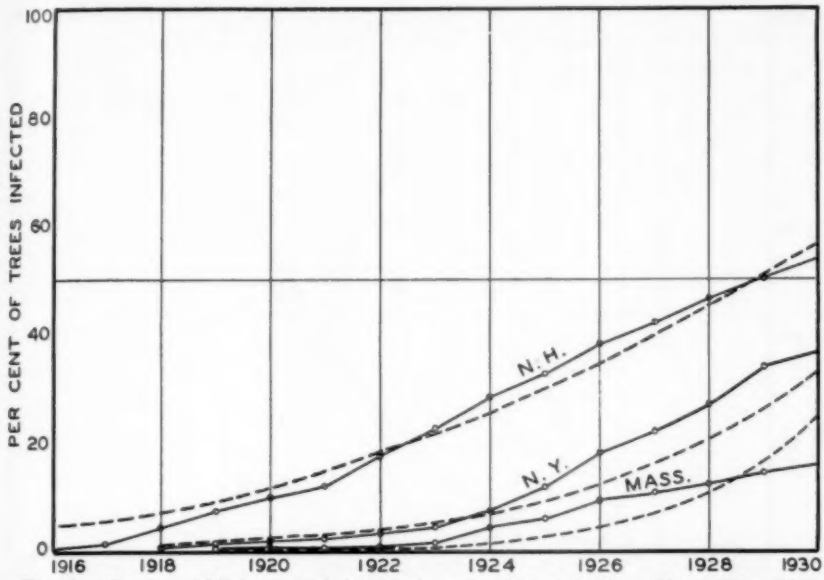

Fig. 3.—Course of blister rust infection in several plots in New Hampshire, New York and Massachusetts. In fitting the logistic curves (broken lines) the New Hampshire data for only 1920 to 1931 were used; for other states complete data were used.

tual percentages of trees that were infected on the date shown, as determined by the internodes on which the cankers occurred.

The middle unbroken line in this same figure represents data obtained from seven unprotected plots containing 4445 trees in Warren and Essex counties, N. Y., while the lower unbroken line represents the course of infection in one unprotected plot of 2061 trees in Massachusetts.

The small triangular points in fig. 4 give the same information with respect to seven unprotected plots in Clarion county, Pa.

Let us now return to the curves of population increase worked out by Verhulst and by Pearl. The equation[2] for the curve, as modified for our

[2] The equation is given by Pearl as $y-d=\frac{K}{1+Ce^{-rt}}$. Of the terms in this equation, d and K represent merely the lower and upper limits of population respectively. In adapting this equation to infection percentages we substitute 0 and 100, respectively, for these terms; e represents the base of Napierian logarithms, and as r is a rate of change to be calculated from the data, we can let 10^m stand for e^r. In this way tables of common logarithms can be used in making the necessary calculations. The figure m is always a minus quantity. The more

present purpose, is $i=\frac{100}{1+C(10^{mt})}$ where i is the percentage of cumulative infection; t the time in years from any convenient point (t_0) such as the year before the first reported infection occurred; m a figure denoting the rate of increase; and C a calculated proportion between the number of healthy and the number of infected trees in the year taken as t_0.

There are two items in this equation that need to be determined from the data. One of these items is C, which represents the probable number of healthy trees divided by the number of infected trees during the year

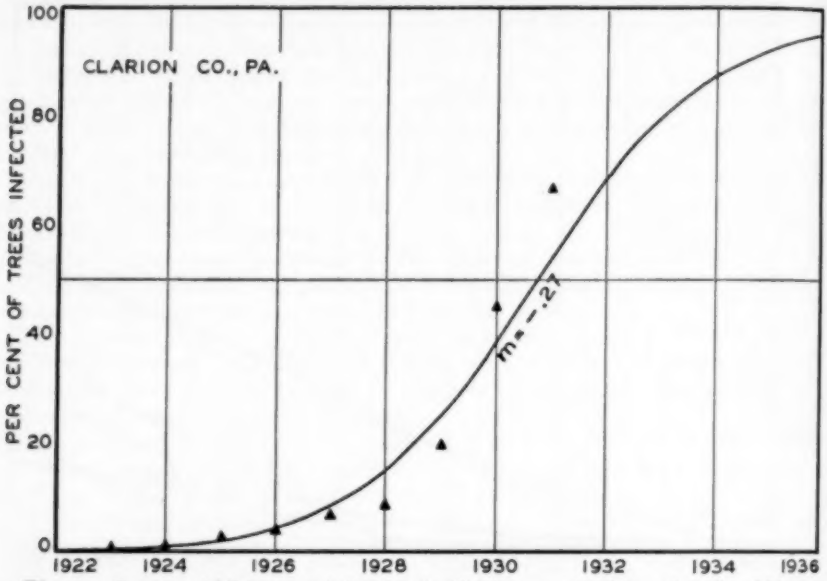

Fig. 4.—Course of blister rust infection in Clarion county, Pa., plots for 1922 to 1931, with course estimated for 1932 to 1936. Triangles show the observed points. See also fig. 9.

which we can arbitrarily select as the starting point. For the Moxie Gore data we might call that year 1915. The purpose of calculating C is to define the relative position of the curve with respect to the arbitrarily determined starting point of the data, without modifying the shape of the curve.

The factor m, representing the rate of increase, determines the degree of slope of the line in the graph. The broken lines in fig. 3 and the solid line in fig. 4 show the estimated or calculated course of infection in the plots in New Hampshire, New York, Massachusetts and Pennsylvania

rapid the increase in population the "larger" m becomes; that is, when m is -1.2, the population increase it represents is twice as rapid as when m is $-.6$. The equation given may be transformed into the straight line form $\log\left(\frac{100-i}{i}\right)=\log C+mt$, thereby making it possible to calculate $\log C$ and m from the data given by the method of least squares. For convenience, the quantity $\left(\frac{100-i}{i}\right)$ is usually written Z.

referred to above, with the points of observation on which the calculations are based. In other words, the graphs are curves fitting the population equation to the plot data by the method of least squares.[3]

It appears from graphs published by Lachmund (*4*, fig. 2), which are not repeated in this paper, that the rate of killing of *Pinus monticola* by blister rust by height classes may be represented by S-shaped curves similar to those applicable to the rate-of-infection increase of *Pinus strobus* in the east. We shall refer to Lachmund's observations in more detail a little later.

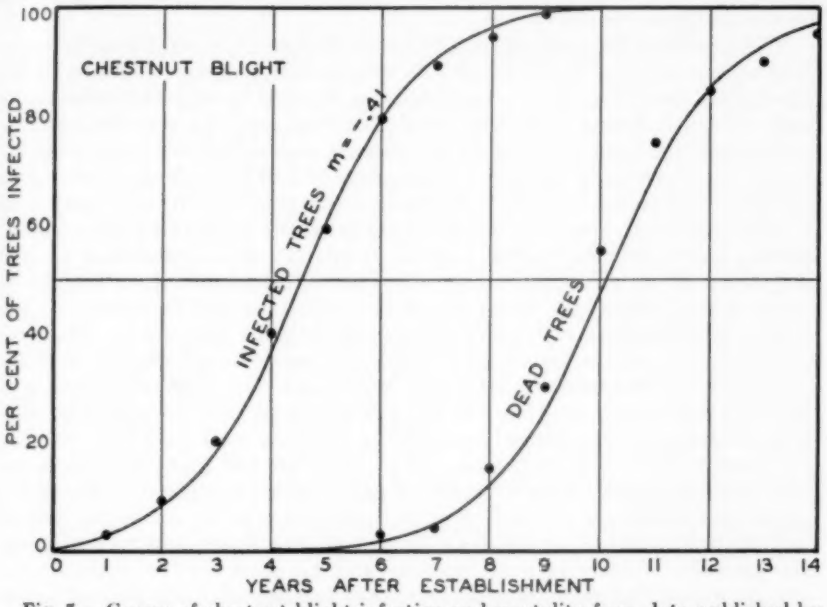

Fig. 5.—Course of chestnut blight infection and mortality from data published by Gravatt & Gill (*3*). Points represent data; lines show fitted logistic curves.

Before taking up the practical importance of these observations and some of the complicating factors, I should like to refer in passing to another introduced epidemic disease, the chestnut blight, *Endothia parasitica*. In 1930 Gravatt & Gill (*3*) published a table in which they gave the progressive increase of chestnut blight infection in a locality year by year after it had arrived, showing that about 10 years elapse from the time of the infection's arrival until it reaches approximately 100 per cent (more than 99.9 per cent). In that publication the table is not shown in graphic form but the list of percentages is given. Figure 5 shows a

[3] The normal equations for finding m and C from the observed data are:

$$\Sigma \log \left(\frac{100-i}{i}\right) = n \log C + \Sigma(t)m$$

$$\Sigma t \log \left(\frac{100-i}{i}\right) = \Sigma(t) \log C + \Sigma(t^2)m.$$

graph of these percentages. The senior author of that paper informs me that, at the time the paper was published, the authors were not familiar with the Verhulst population curve and that their data were based entirely on observation and not on an idea that the progressive intensification followed any particular mathematical pattern. Under these circumstances, the closeness with which the infection percentages follow the Verhulst population curve is almost startling. The infection percentages as given by Gravatt & Gill are shown by spots in the figure, while the line represents a Verhulst curve fitted by the method of least squares to the Gravatt & Gill data. The rate of increase in this case proves to be $m = -.41$.

The practical importance of the use of this population formula is the ease with which the factor m, or rate of increase, may be calculated from the known past history of a particular plot, even though the infection is still of very low degree and of brief standing, and the resulting ability to forecast the future course of the disease *as long as the local conditions remain approximately the same*. The apparent fact that the general course of blister rust infection follows the line of this population curve may help to interpret field data. By checking actual *Ribes* conditions with the resulting course of infection in typical situations, it is hoped that we will be guided in our efforts to determine where control measures need to be applied most promptly, how much *Ribes* live stem may be missed by the crew without running the risk of endangering the pine plots, where reeradication work can be postponed without danger, and where it is of the most pressing importance. By this same means, although we cannot now see the cankers produced on the trees in 1934 and 1935 and can find only a small proportion of those produced in 1933, nevertheless by recording the past history of the disease up to 1932 an the plot concerned, we can determine with a high degree of nicety the percentage of trees in a given plot which are now infected. It further becomes possible by following the first build-up of infection from 0 to 5 or 6 per cent to determine the probable future rate of increase and to omit control measures in stands where the increase is so slow that commercial loss cannot be expected.

Accordingly, the first tool of interest is the method of calculating the rate of increase shown by the factor m in the logistic curve. Having determined C, which supplies us with a starting point to date the curve, and m, which shows the rate of increase, the course of infection can be shown graphically for each region or plot in which we are interested.

The most surprising thing about these plot studies has been the way in which the increase in infection has been so persistent and continuous in spite of varying weather conditions, and the extent to which, in the northeastern states at least, the supposed triennial waves of infection based on the three-year life cycle of the fungus overlap one another after the early establishment of infection so that they seem to disappear entirely as separate waves. In each of these states, after the disease has passed through its first few early years of establishment on a few trees, and thus has developed its basic supply of aeciospore-bearing cankers, its progress is steady and its increase inevitable, with little regard for the

vagaries of humidity, rainfall and wind velocity.[4] One explanation for the steadiness of its progress may be that almost every year there are a large number of days in the northeastern states in which weather conditions are favorable for blister rust spread, so that the rate of spread depends almost entirely on the relative number and location of the susceptible *Ribes*, the alternate host of the disease, whose presence is essential to blister rust distribution.

On the other hand, although there seems to be little variation from year to year due to differing seasonal weather conditions, differences in the *Ribes* population have a most pronounced effect.

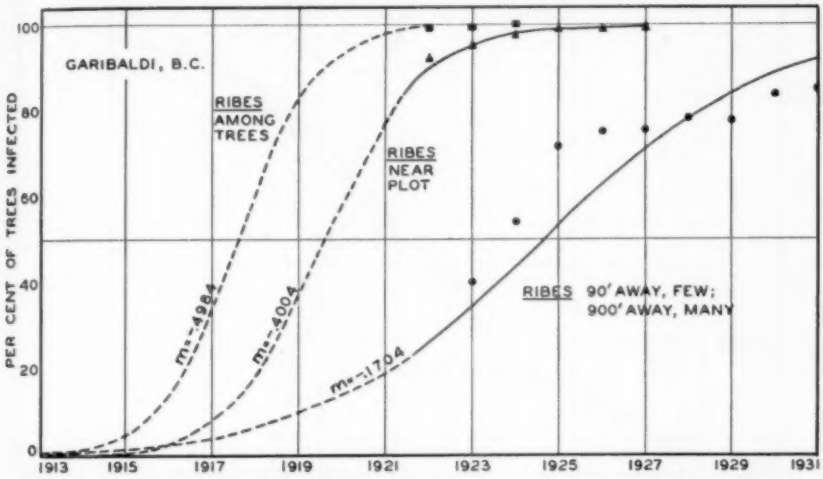

Fig. 6.—Rate of increase (m) depends on exposure to *Ribes*. Based on three plots near Garibaldi, B. C. (*4*). Points represent data, lines show fitted logistic curves.

Figure 6 is a graphic representation of the data given by Lachmund (*4*) for study areas in natural reproduction of western white pines, *Pinus monticola*, near Garibaldi, B. C. In these plots the course of infection was determined by successive annual observations rather than by dating the cankers from the internodes on which they occur. Accordingly, only a small fragment of the history of infection is included. The plots were first exposed to infection in 1913. The pines in plot 1 were growing among *Ribes bracteosum*, a highly susceptible species, those in plot 2 were adjacent to *Ribes bracteosum*, and there were a few *Ribes lacustre* in the plot, while the pines in plot 3 were "about 300 yards northeast of the area of the heavy growth of *Ribes*, but a few scattered bushes of *Ribes lacustre* and *Ribes sanguineum* (red-flowering currant) grew within 30 yards of it." The probable course of infection from 1913 to the time observations started in 1922 is shown by the dotted lines of the left half of

[4] When waves of infection occur, the infection points in a graph appear in a steplike arrangement instead of an even curve. Such a case from British Columbia is shown in the infection points for the lower curve of fig. 6.

the graph, fig. 6. The feature of interest here is that the slope (*m* in the equation) is determined by the *Ribes* conditions.[5]

Changes in the rate of increase.—The most common change in *Ribes* population under present conditions consists of artificial *Ribes* eradication carried out as a control measure for the protection of the pines. Figure 7 shows how such *Ribes* eradication permanently interrupts the course of infection. This graph represents the record of 15 plots with 7171 trees in five counties of New Hampshire, New York and Vermont protected by *Ribes* eradication 1925–27, and studied in 1934. This result of eradication is proving true throughout the entire white pine area under

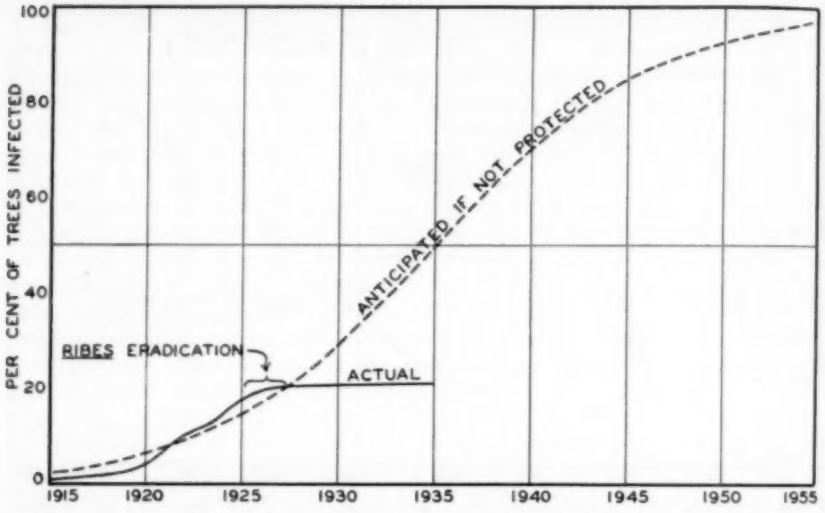

Fig. 7.—*Ribes* eradication stopping course of infection. Based on 15 plots, 7171 trees, in five counties of New Hampshire, New York and Vermont, protected in 1925–27, examined in 1934.

ordinary standard conditions of *Ribes* eradication, even though it is well known that under such conditions the last small percentage of *Ribes* plants are seldom or never found and destroyed. The rate of increase of blister rust in a given area depends on the number and nearness of the susceptible *Ribes*, and the breakdown of the *Ribes* population definitely stops that rate of increase.

There is another type of change in the *Ribes* population, however, that is well known and to which we may now direct attention, that is, the gradual change due to ecological conditions. Those who have been working on *Ribes* ecology classify *Ribes* environments in three groups: first,

[5] The exact position and shape of these curves is calculated on the assumption that the first tree became infected in each plot in 1913 and that the last tree became infected during the year shown by Lachmund as "100 per cent." The important feature of the Lachmund data for our present purpose is the fact that, to reach the recorded infection percentage in 1922 from a disease-free condition in 1912, the rate of increase must have been much more rapid from the time the infection was 20 per cent until it reached about 70 per cent than it was either earlier or later.

newly disturbed or recently cut-over areas, or stream valleys, "live" swamps, and fertile open uplands, where the *Ribes* are vigorous and increasing; second, thin forest stands with a certain amount of shade in which the *Ribes* population is likely to be stable; and third, conditions under which the forest is so dense and the shade so heavy that *Ribes* do not thrive and the *Ribes* population is naturally gradually decreasing.

When we were discussing above the various types of population curves exhibited by blister rust infection in different areas, we were interested

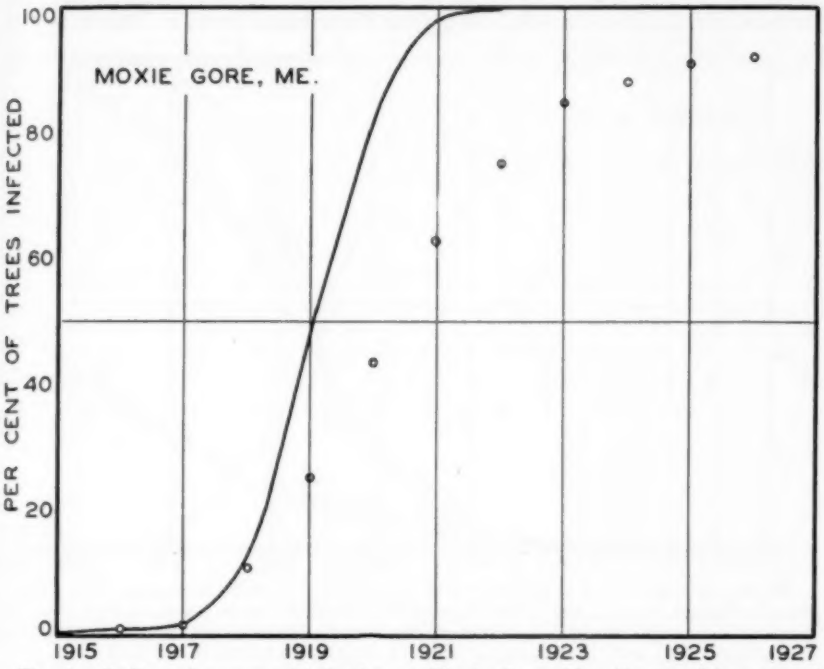

Fig. 8.—Indicated course of infection at Moxie Gore, Me., if rate of increase of first three years had remained unchanged. Small circles represent percentage of actual infection.

primarily in the degree to which blister rust infection *resembled* the standard population curve and how closely these curves fitted the data. In spite of these resemblances, however, many cases show certain differences, and for a long time one class of difference, namely, a sort of steady distortion, proved especially puzzling. If we were to take the infection data of the Moxie Gore plantation in Maine and had before us data only for the the first two years of infection, we would find that the rate of spread (m) in the formula was represented by the figure -1.24, under which 75 per cent infection could be anticipated by 1919. If we recalculate it, based on the first three years of infection, m appears to be -1.005, fig. 8. Taking the first four years of infection, we find that the increase is now at the rate of only $-.838$. Five years shows it to be $-.705$. If we

take the first six years we find it is only −.616, while the final figure from all the data as taken in 1930 shows it to be −.365, which brought 75 per cent infection in 1922. In other words, the rate of increase, if the disease was strictly following the course of the logistic curve, was continually becoming less.

On the other hand, if we handle the plots in Clarion county, Pa., in the same manner, we find that data for the first two years indicate that the rate of increase (m) is 0, based on the first three years −.152, based on the first four years −.227, while the full data (1922–31) give the rate m as −.27. In other words, each year for several years a little more in-

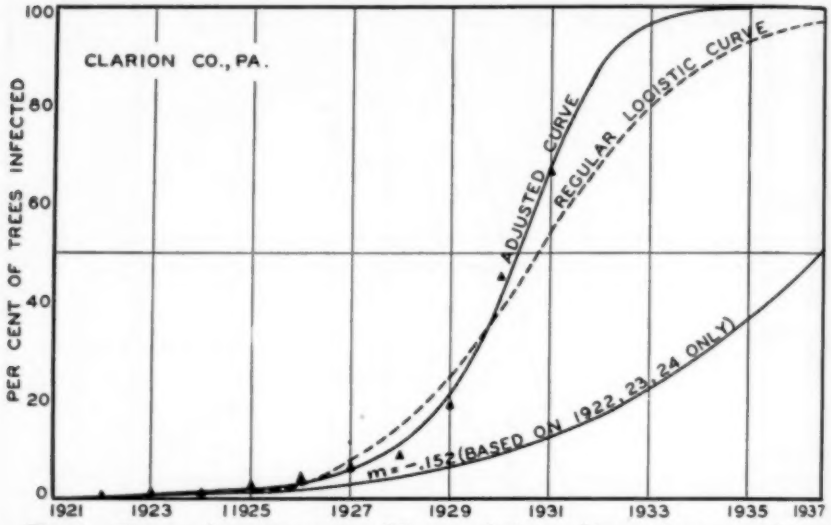

Fig. 9.—Changes due to increasing *Ribes* population and increasing rate of infection in Clarion county, Pa. Lower line shows a logistic curve based on first three infection years only; the broken line a regular logistic based on all the data; and upper line a curve adjusted to a changing infection rate as explained in the text.

fection actually developed than would be expected from the past history of the plots. If the rate of increase had continued only at that for the first three years, 66 per cent infection would not have been reached until 1939 (see lower line in fig. 9), whereas it was actually attained in 1931.

Reviewed in this way, the explanation seems to be perfectly clear. Ecological conditions in the Moxie Gore plot were resulting in the gradual suppression of the *Ribes*. Instead of having a constant infecting factor, the source of inoculum was becoming smaller each year. At the time of examination, the trees ranged from 6 to 20 feet in height, averaging 15 feet. They had been planted about 6 by 6 feet; accordingly the *Ribes* among the trees were gradually becoming suppressed and no outside increase was occurring in sufficient degree to balance the suppression.

On the other hand, the pines in the Clarion county plots were growing under conditions where the *Ribes* were vigorous and increasing. Instead

of having a constant inoculating source, infection was coming from an ever-increasing number of *Ribes* leaves.

This progressive or continual change means that a given length of time was not having the same effect in the later years of infection as it was in the earlier. At Moxie Gore 1920 or 1921 had more influence than 1925 or 1926. This can often be taken care of in the population-curve equation by changing the time factor, that is, the number of years since infection started, to a parabolic form and using in place of mt the expression

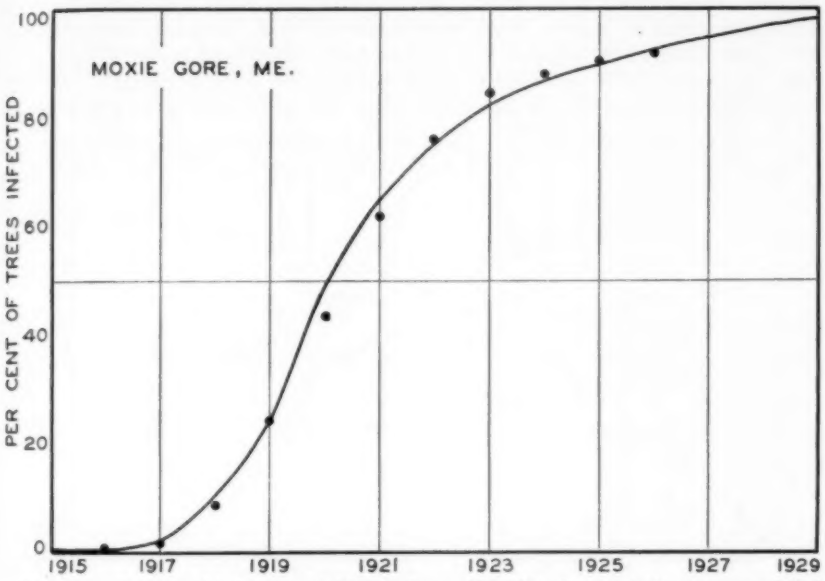

Fig. 10.—Course of infection at Moxie Gore, Me., fitted to logistic curve modified by third-order parabola, to provide for the progressive retarding of rate of increase, accompanying the natural suppression of the *Ribes*.

$mt+at^2+bt^3$. The new constants a and b represent acceleration.[6] Figure 9, upper line, thus shows how close a fit is obtained in the case of Clarion county, Pa., when we use the modified parabolic curve in place of the simple population curve. The latter, and also the preliminary curve based on only the first three years of observation, are shown for comparison. Similarly the closeness of fit in the Moxie Gore area is shown in fig. 10; here, if we take 1915 as t_0, the equation is:

$$i=\frac{100}{1+[15{,}600\times 10^{-1.428t+.146t^2-.00547t^3}]}.$$

[6] The normal equations, for calculating C, m, a and b, in the transformed formula $\log C+mt+at^2+bt^3=\log\left(\frac{100-i}{i}\right)$, are

$$\begin{aligned}
n\log C+\Sigma(t)m+\Sigma(t^2)a+\Sigma(t^3)b&=\Sigma\log Z\\
\Sigma(t)\log C+\Sigma(t^2)m+\Sigma(t^3)a+\Sigma(t^4)b&=\Sigma(t\log Z)\\
\Sigma(t^2)\log C+\Sigma(t^3)m+\Sigma(t^4)a+\Sigma(t^5)b&=\Sigma(t^2\log Z)\\
\Sigma(t^3)\log C+\Sigma(t^4)m+\Sigma(t^5)a+\Sigma(t^6)b&=\Sigma(t^3\log Z)
\end{aligned}$$

Accordingly, the second tool which is suggested for the study of changes in infection and plant disease population is that of calculating acceleration factors (*a* and *b*) to represent the degree to which the environment is becoming more, or less, favorable to the organism.

Geographical distribution of the source of spores.—We now come to a third phase of this same problem—the relation between the number of cankers in an infected stand and the number of infected trees. Fiske (*2*) in 1910 became interested in the problem of how the number of parasites in each individual gipsy moth larva compared with the percentage of infestation in the region. Fiske had observed that the adult female parasite was apparently unable to discriminate between larvae which were already parasitized and those which had not yet been attacked. Accordingly, the chances that a particular egg would be laid in a gipsy moth

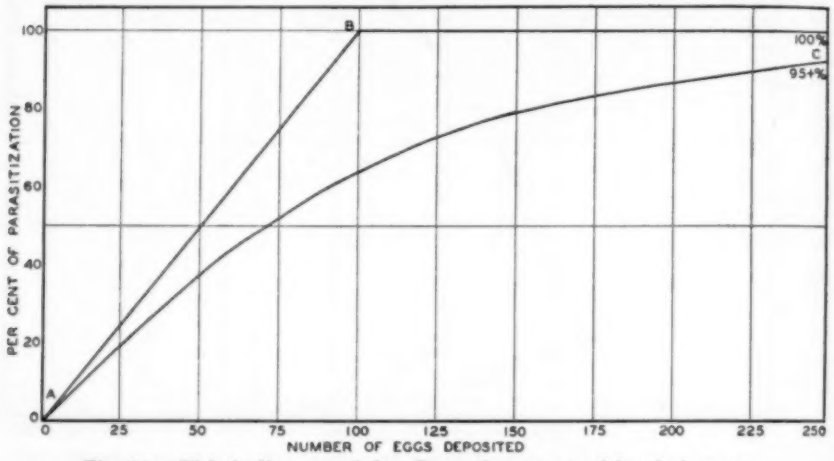

Fig. 11.—Fiske's diagram of the effects of superparasitism in insects.

larva which was already parasitized depended entirely upon the proportion of such parasitized larvae to the general larval population. That is, if 25 per cent of the larvae were already parasitized, one egg out of four thereafter would be laid on an already parasitized larva, and the other three would result in the infestation of three new and additional larvae. Fiske's curve is shown in fig. 11.

Fiske worked out his graph by calculating the probabilities from point to point but did not give an equation for it, presumably using the methods of computing probability described in mathematical textbooks. W. R. Thompson (*6*) in 1924 developed this conception as a differential equation and published not only the formula concerned but also a table to aid the reader in plotting the curve accurately. The equation is $i = 100(1 - e^{-.01p})$, where i is the percentage of infestation, p is the probable number of parasites per 100 total host larvae, and e is the base of Napierian logarithms. Like Fiske, Thompson did not publish any field observations to show whether the theoretical curve represented the con-

ditions that actually occurred in nature, but more recently Clausen, Jaynes, & Gardner (*1*) have reported observations on a parasite of the Japanese beetle, showing that the number of parasite eggs per 100 beetles approximately follows the equation given.

It seems a far cry from the study of insect parasitism to the epidemiology of white pine blister rust, but the same principle seems to be in operation. When a blister rust sporidium from a nearby *Ribes* reaches a group of pine trees under conditions favorable for the formation of a blister rust canker, it is clear that, other things being equal, the chance of such a sporidium resulting in the infection of a previously healthy tree depends on the percentage of infection at that moment in the stand concerned. That is, if 25 per cent of the trees are already infected, of four new sporidia reaching the stand and causing infection, the chances are

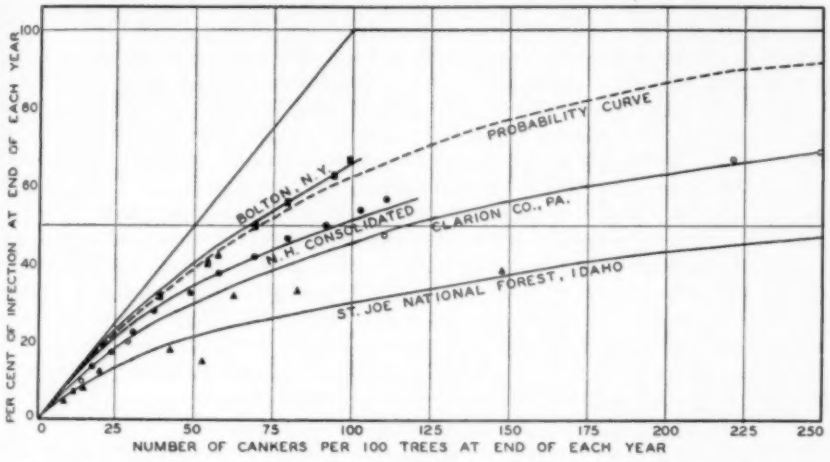

Fig. 12.—Actual relations between infection percentages and number of cankers per 100 trees in one plot at Bolton, N. Y., 16 plots in New Hampshire, seven plots in Clarion county, Pa., and 52 strip lines, each half a mile long, in the St. Joe National Forest in Idaho. For comparison with the probability curve, also shown.

that one of them will result in an infection on a tree which already has a blister rust canker, while the other three will infect three previously healthy pines. Under certain types of *Ribes* distribution these laws of pure chance do not apply, as will be pointed out in a few minutes.

Figure 11 may thus now be taken to show graphically the situation when all pines in the stand are equally accessible to the source of sporidia. The vertical scale now represents the percentage of infection; in other words, the number of infected trees out of every 100 trees in the stand, while the horizontal scale represents the number of cankers for each 100 trees in the stand. The straight diagonal line shows the minimum number of cankers which could possibly be existing for the degree of infection concerned. That is, if 80 trees out of 100 are infected, at least 80 cankers must be present. The curve line shows the effect of the operation

of the laws of chance. Thus when 80 per cent of the trees are infected, the chances, following Fiske's and Thompson's reasoning, are that 161 cankers will be present.

It will be observed that this is a perfectly rigid formula which admits of no modifications of any kind. It states, in effect, that with a given infection percentage, the number of cankers per 100 trees will always be a specific number. For example, if 35 per cent of the trees are infected, 43 cankers would always be found in each 100 trees in the stand. If 50 per cent of the trees are infected, 69 cankers would always be found for every 100 trees in the stand.

With this as a background, your attention is now invited to fig. 12, which shows a series of observations as to actual field counts. In most of these observations, the number of cankers present was compared with the infection percentage each year on the plots concerned, thus giving a number of points of observation for each plot. In the case of the St. Joe forest in Idaho, however, the records are for 53 separate strips, each half a mile long and 1 rod wide, grouped by infection percentages.

It will be noted that, in the case of every plot but one, the actual number of cankers in the plot is greater than would be indicated by Fiske's curve and Thompson's equation,[7] but that amount of divergence between the field data and the theoretical curve is consistent. The writer has found that the difference between the theoretical number of cankers p and the actual observed number c is a constant fraction of the square of the probable number of cankers. The relation is therefore represented by the formula: $c = p + dp^2$, where c is the actual number of cankers, p the theoretical number of cankers, and d a constant for the plot concerned, to be obtained from the data. The larger this constant factor (d) is found to be, the greater the difference between the observed number of cankers per 100 trees and the theoretical number.[8]

The important feature of this situation is the factor indicated by d in the equation. Let us try to see what this factor represents. The possible distance of distribution of sporidia in the case of white pine blister rust is very limited, owing to their tender nature and brief life. The number surviving to infect pines at distances of more than 900 feet from the usual species of wild *Ribes* is negligible for commercial forest production. It is clear, therefore, that if all the *Ribes* causing infection in a stand are concentrated at one point on the margin of the stand, not all the trees in that stand have the same danger of becoming infected.

Returning to the same illustrations used earlier, if, at a time that four sporidia are released from the *Ribes*, 25 per cent of the stand is already infected, and if the *Ribes* are limited to a single group, this 25 per cent will largely be in that part of the stand which is nearest the *Ribes* plants.

[7] In an unpublished manuscript made available to the present author, Lachmund shows a sketch of this same probability curve without giving the equation, and notes that the number of blister rust cankers in *P. monticola* is consistently greater than this curve would cause one to expect. Before knowing of Lachmund's work, the same conclusion had been reached by the present author with respect to *P. strobus*. The explanation of this difference from the probability curve, and the method of measuring it by the use of a distribution factor d, are original with the writer.

[8] The normal equation for finding d is $\Sigma c = a(0) + \Sigma p + d\Sigma p^2$, and can be expressed by the formula: $d = \frac{\Sigma(c) - \Sigma(p)}{\Sigma(p^2)}$.

Accordingly, the laws of pure chance are no longer operating with respect to the entire stand, but it is probable that, instead of three of these spores reaching previously uninfected trees, perhaps only one or perhaps none will reach healthy pines. In 100 trees of which 25 are infected, under these circumstances, we may thus find dozens or hundreds of cankers instead of only 29 cankers—the theoretical number. On the other hand, if we have widely distributed upland species of *Ribes* scattered among the trees, the laws of chance are quite likely to apply and the curve will be very close to the theoretical limit.

We have noticed that the farther the observed data depart from the theoretical expectations, the larger the *d* factor in the equation becomes. The factor *d* now becomes a measure of the extent to which the local ecological features prevent a uniform distribution of spores throughout the pine stand. For practical purposes it represents largely *a measure of the effect of* Ribes *distribution on the spread of infection into the pine stand.* The *d* factor is small where the *Ribes* are scattered evenly throughout the entire stand or where from some other cause the spores are being distributed evenly over the pines, larger where the *Ribes* occur in patches here and there, and reaches a maximum when the source of *Ribes* infection occurs at one side of or in one direction from the pine stand itself.

It will be noted in fig. 12 that in the Bolton, N. Y., plot the probability curve is followed almost exactly, *d* in fact being a very small negative quantity. In that part of eastern New York *Ribes* are generally distributed. In the New Hampshire plots *d* is +.00504, showing on the whole a nearly equal general distribution of such susceptible species as *Ribes cynosbati* and *R. hirtellum* throughout the stand. In the Clarion county, Pa., plots, *d* is +.0098, reflecting the somewhat more spotted distribution of *R. rotundifolium*, the dominant species there; while in the St. Joe National Forest in Idaho *d* proves to be +.0462, in accordance with the greater dominance of the stream-type distribution where the more susceptible *Ribes* occur primarily in narrow strips through the stand.

For the purpose of the analysis of pine infection data, this *d* becomes the third tool which can be used in the study of the development of blister rust epidemics. It is now presented for the first time and it represents the first method we have had for gathering together all the complicating factors of local *Ribes* distribution, and separating the effect of the distribution of the *Ribes* with relation to the distribution of the pines from the other factors operating in the stand.

This exploration of certain phases of mathematics, plant disease outbreaks and insect parasitology was undertaken in a search for some regularity, some thread of meaning, some general laws governing the very diverse ways in which white pine blister rust and similar organisms operate. Modern theories of atomic physics indicate that atoms disintegrate under such conditions that the direction of the disintegrating particles cannot be anticipated or foretold. In the same way the spores and sporidia of the blister rust are carried in every direction by the passing wind. These new developments in physics have not caused any breakdown in the confidence of physicists that solids, liquids and gases taken

in appreciable quantities will continue to respond to the same physical laws that have governed them for centuries. In the same way the indications from the present study are that, however haphazard and unpredictable may be the course of an individual sporidium, the progress in the intensification of the disease itself is almost as regular and steady and measurable as the laws governing the expansion of gases.

Summary.—The writer's conclusions are that the progressive intensification of white pine blister rust follows the same general type of development as that of human population and that there are several convenient ways in which it can be measured: first, *the rate of increase* may be represented by *m* in the logistic curve used in studies of human population; second, the extent of the *gradual suppression of or increase in the* Ribes *population*, the most important factor in the environment from the blister rust standpoint, can be determined by introducing appropriate coefficients to represent acceleration in the same population equation; and third, the *effect of the distribution* of the *Ribes* in a given environment can be measured by finding out how many more cankers are present per tree in the stand, in view of the percentage of infected trees, than would be there if the *Ribes* were scattered uniformly among the trees.—8-19-36.

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ERADICATION OF CITRUS CANKER AND CONTROL OF PHONY PEACH AND PEACH MOSAIC

PROGRESS REPORT

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Phony peach and peach mosaic, both virus diseases of the peach, and citrus canker, a bacterial disease of citrus, are objectives of control and eradication projects which are being conducted by the Division of Do-

mestic Plant Quarantines of the Bureau of Entomology and Plant Quarantine.

The regular projects pertaining to phony peach disease control and citrus canker eradication were transferred from the Bureau of Plant Industry to the Bureau of Entomology and Plant Quarantine on July 1, 1934. This progress report will therefore cover the 18-month period beginning with that date. The emergency relief project relating to peach mosaic survey and control was begun in August 1935.

Phony peach control.—The control of phony peach has been a federal activity since 1929. At present this disease is known to exist in 15 states located in the southeastern quarter of the United States. The infection is heavy in Georgia and Alabama, general in all the other Gulf coast states west through Texas, and light and spotted in North and South Carolina, Tennessee, Arkansas, Oklahoma, Missouri, Illinois, Kentucky and Maryland.

Phony peach belongs to the yellows group of peach virus diseases, but differs from the other major diseases of this group in that it is apparently limited to root infection. The disease cannot, therefore, be disseminated by fruit, seeds, budding wood or surface parts of the plant, which is an important and encouraging factor in control activities. The only known method of artificial dissemination is through the medium of infected nursery stock.

The agency of natural spread has not been determined, but suspicion has pointed to the peach borer as the possible vector. Current investigations by the Bureau of Plant Industry to determine this point are, we understand, sufficiently advanced that a fairly definite indication should be secured during the 1936 growing season. It is known, however, that natural spread is local and comparatively slow, partly because of the long incubation period of 18 months or more.

In view of what is known of the natural and artificial spread of this disease, the control measures now adopted comprise three distinct functions, which are named in the order of their importance:

(1) Careful and thorough annual inspections and the removal of diseased trees in the environs of peach-growing nurseries throughout the known infected area, and assisting state agencies in culling from peach nursery stock all borer-affected plants.

(2) An annual survey beyond the northern limits of known infections for the purpose of determining any extension of spread, and careful inspection and eradication in the lightly infected states and in the border zone of infection.

(3) An intensive inspection followed by removal of diseased trees in the commercial belt of the heavily infected area of the southeast.

The first two functions have a direct bearing on prevention of spread; the third function is more specifically in the nature of direct control and is beneficial primarily to the immediate commercial industry. This phase of the work, however, has conclusively demonstrated the practicability of control, as evidenced by the reduction in the number of diseased trees in the more heavily infected area from 177 per thousand in 1929 to less than 20 per thousand during the last two inspection seasons. The peach

industry in this area, which was in a demoralized condition a few years ago, owing primarily to the heavy losses resulting from this disease, is now being revived and expanded. Growers still recognize the seriousness of this disease, but they no longer feel that it marks the end of profitable peach production.

One of the problems of effective control was the reinfection of orchards from nearby diseased, abandoned and escaped peach trees, the removal of which was outside the scope of regular federal actitvies and beyond the means of available regular funds. An allottment from the Emergency Relief appropriation in the amount of $840,000 is now being expended for the removal of these trees by a force of 2000 men employed in 129 counties of 11 states in the infected area, and during the last four months more than two million abandoned and three and one-half million escaped peach trees have been removed.

Other activities for the 1935 season comprised the inspection in 12 states of the environs of 113 commercial peach nurseries, 26 of which were exposed to infection, and the inspection of 9,300,000 peach trees in 34,500 orchards located in 18 states. Of these trees, 66,000 were found to be infected and are being destroyed.

Citrus canker eradication.—Citrus canker, an extremely infectious and destructive bacterial disease of citrus, was apparently introduced from Japan on *Citrus trifoliata* root stock in 1911, and during subsequent years it became established in 79 counties in seven states embracing the Gulf coast citrus area from Texas to Florida.

Federal and state activities directed towards the eradication of this disease have been in progress for more than 20 years, and represent a total expenditure of nearly five million dollars.

Eradication of citrus canker was apparently accomplished prior to 1928 in all the Gulf coast areas except a noncommercial district in Texas and Louisiana; most of the work incident to this undertaking has therefore long since been completed. The very difficult task, however, of destroying the last vestige of this disease in the United States, which marks the vast difference between complete eradication and effective control, still remains to be accomplished.

The area now known to be infected is that in which Satsuma orange production was undertaken on an extensive scale 20 to 25 years ago but, owing to the ravages of citrus canker and to severe winter kill, the enterprise was abandoned as a commercial industry. The cold-resistant *C. trifoliata* root stock, however, not only survived but has become naturalized, and infected plants are now being found intermingled with native growth long distances from original plantings. Eradication is therefore very difficult and necessitates thorough, intensive and systematic inspection under adverse conditions.

Citrus canker has been found during the last 18 months in noncommercial citrus areas in three Louisiana parishes and in four Texas counties.

In the fall of 1934 three properties with one diseased tree each were discovered in Lafourche and Terrebonne parishes in Louisiana. Intensive inspection was continued throughout the citrus area of that state, but no additional infections were discovered until the fall of 1935, when two

infected properties were located in Terrebonne parish, one in St. Charles parish and four in Lafourche parish. There were 913 diseased trees on the seven properties. The inspection activities in Louisiana for many years have been systematic and thorough except in a few densely wooded areas of escaped *C. trifoliata*. It was in such areas that the seven 1935 infections were detected by intensive inspection, which was made possible only by the clearing out of jungle growth by relief labor.

From 1929, when Texas was thought to be free of citrus canker, to June 1934, several infections were located in the Houston-Galveston area most of which were recent and recurring infections in yard plantings. To locate the sources of such infections the inspection procedure in this state was readjusted in the fall of 1934 and intensive inspection was begun of all wooded areas, ditch banks, fence rows and pasture lands. As a result, a total of 41 infected properties, comprising nearly 1400 diseased trees, were located in four counties in the Houston-Galveston-Beaumont area. Thirty-nine of these infections were found during 1935, five of which were discovered on December 17, near Beaumont in Jefferson county, an area in which no infections had been reported for 16 years. All of these infections, many of which were of long standing, were on abandoned or escaped citrus plants.

To facilitate systematic future inspection and eradication, the locations of all citrus plants have been carefully charted on topographic maps during the course of the regular inspection. On the basis of these records relief laborers have removed since August 1935 more than one and a half million trees, including all citrus, on over 98 per cent of the recorded properties in all areas worked. Funds for citrus canker eradication, made available from the Emergency Relief appropriation, will permit similar eradication to be conducted in the remaining citrus-producing counties in the Gulf coast region of Texas and Louisiana.

Peach mosaic control.—Peach mosaic, the newest of the five peach-virus diseases, was first observed in Texas in 1931 by federal phony peach inspectors and was identified by Dr. Lee M. Hutchins, of the Bureau of Plant Industry, as a previously unknown virus disease. Subsequent surveys revealed the presence of this disease in 10 widely scattered counties in the noncommercial peach area of central Texas. A disease that proved to be peach mosaic was reported by Colorado in May 1934 as occurring in the commercial peach belt of Mesa county, Colorado, where it had apparently been present for four or five years.

In the spring of 1935 the state of Colorado undertook an intensive eradication campaign, which was supplemented in August 1935 by a federal relief work project.

As reported by Dr. Hutchins, the disease is infectious and may be transmitted by budding or by patch-bark grafting from either twig or root bark; the incubation period is apparently less than 12 months, and the natural spread is generally in colony formation. The agency of natural spread is unknown, but the appalling rapidity with which the infection advances is evidenced by the records of one orchard of over 1200 trees in Mesa county, Colorado, which showed two infected trees in 1929, approximately 10 in 1931, 100 in 1932, 200 in 1933, 500 in 1934, and all

but 13 in 1935. All of these infected trees were removed by eradication workers. A survey of the Palisade area of Mesa county made during the summer of 1934 by E. W. Bodine, assistant pathologist of the Colorado Agricultural Experiment Station, indicated approximately 3000 diseased trees. A year later over 30,000 diseased trees were removed from this area.

Eradication work by the emergency project will be continued in the infected area of Colorado during the spring and summer of 1936 and, during the same period a survey will be conducted in Colorado, New Mexico, Texas, Kansas, Iowa and Nebraska.

The activities of these projects are conducted in cooperation with the several affected states, which have rendered material financial and personnel assistance.—9-16-36.

EUROPEAN CORN BORER SITUATION IN WISCONSIN

E. L. CHAMBERS, *Wisconsin State Entomologist, Madison*

Having in 1870 witnessed one insect, the chinch bug, transform their wheat-growing state to the dairy state it is today, Wisconsin farmers have looked with fear upon the European corn borer ever since its introduction into this country in 1917, lest it might in turn play havoc with their dairy industry. With 3,200,000 cattle on 93 per cent of Wisconsin's 200,000 farms, the state naturally gives serious consideration to any agency which might make its basic industry unprofitable.

Although a more or less careful lookout has been maintained in Wisconsin for the borer since its first discovery in this country, with special emphasis placed in areas around sweet-corn canneries, and broom-corn factories, it was not until 1931 that the first specimens were found in the state. A state quarantine was established against materials capable of spreading this pest from infested areas of the east soon after the borer had gained a foothold there, and was maintained until replaced by a federal quarantine and again put into effect two years ago after the latter had been withdrawn.

First infestation found in 1931.—Active scouting in cooperation with the federal government in some 20 counties bordering Lake Michigan, with as many as 24 scouts working during each summer, was started in 1927. The first infestations were found in August of 1931, when less than a dozen larvae were found in three hills of early planted field corn on two farms, a mile apart in Sheboygan and Manitowoc counties. These fields and others within a mile were carefully cleaned up by the federal government the following spring, and no borers were discovered in these counties in 1932. Several specimens, however, were taken in a garden plot in Racine county. The sweet corn and field corn for a mile around this particular plot were cleaned up during April and May by our department, which supervised unemployed local labor paid from our own funds. In 1933 a few infested stalks were found in 30 fields of the state

in the earliest planted field corn. These were distributed in 19 townships in 10 counties bordering the lake, from Door to Kenosha county. These and nearby fields were thoroughly cleaned up with local unemployed men hired out of our appropriation; then in 1934, two infested fields were again found in Sheboygan and Manitowoc counties, both having a half dozen hills with a couple of larvae each. Again the fields were cleaned up in the vicinity of the infestation, the owners being paid for doing the work, under the supervision of the department at the rate of $2 per acre, as provided in recent statutes for extra labor required in addition to the regular field practices. During the summer of 1935 the scouting was begun in the middle of July and infested stalks were found as early as the first week in August, although the corn was a little behind its growth for a normal season.

When our regular scouts began finding light scattered infestations, it was decided to put on additional men, and in cooperation with the federal government a relief project was set up. In this project six of our entomologists, who had had previous experience in scouting, were assigned under a federal supervisor to supervise and train 10 crews of five men each taken from the relief rolls. Scouting by these men was carried on for a period of nearly two months and practically all fields in the two tiers of counties along the lake were carefully scouted. These men proved to be surprisingly efficient considering their type of training and lack of experience, and infestations were found in 133 fields in 66 townships and 12 counties.

Borer spreads across Lake Michigan.—It had been realized from the beginning that the borer would eventually reach Wisconsin but it was considered most likely that the spread would be around the south end of Lake Michigan rather than directly across it, as apparently was the case. Not only were the first borers found at the narrowest point between the Michigan and Wisconsin shores, but the infestation this year was also pretty well concentrated around this point where most of the boat traffic seems to center. Hence it would appear that the female moths had been carried across by boats.

Is a paper quarantine justified?—Plant quarantine officials who spend huge sums to stop traffic by way of enforcing a horticultural quarantine are inclined to refer to quarantines which have no elaborate machinery for carrying out their provisions as "paper quarantines." While no one who has given quarantine matters serious consideration would want to compare the accomplishments of one of these so-called "paper quarantines" with that of an active one, it seems to us that in the case of European corn borer a "paper quarantine" is better than none.

The question has frequently been raised whether the European corn borer quarantine should not be abolished, now that the borer has become rather widespread in the east and since it seems to spread by natural flight whenever conditions are right for its rapid multiplication and weather conditions are favorable at time of emergence. We believe that so long as a "paper quarantine" discourages the long-distance movement of possibly infested materials by keeping the public quarantine minded, and the railroads, boat lines and other carriers are thus kept advised of

the danger with a penalty over them for accepting such materials, the "paper quarantine" has value and should be maintained. Without a quarantine the public would not be aware that there was a danger, and infestation might be spread and built up in alarming proportions as a result of a very few shipments of infested material which would not have been moved if those responsible for its transportation had known there was any danger involved. For instance, the Federal Relief Administrator of our state might have accepted hundreds of cars of baled corn fodder from infested eastern states during 1932 and 1933, when there was such a serious drought in certain Wisconsin counties that practically all the feed had to be shipped in to them. Many of these counties normally have a surplus of feed to ship out and are back in this position today. It is our opinion that without the quarantine the two-brooded strains of the corn borer might have been brought into Wisconsin and probably all through the born-belt states as well. The State Feed Relief Director kept in touch with our office at all times on all purchases of this kind, and refused time and again corn fodder from infested areas although getting feed from other sources meant delay and at times when cattle were almost on the verge of starvation. Not only did the agricultural leaders of the state support the quarantine, but the farmers themselves inquired of the local authorities and requested information from our office as to the safety in accepting the baled corn fodder in question. These farmers intimated that they would rather sell their cattle at any price than take a chance of bringing onto their farms corn which might leave the corn borer behind.

Wisconsin is not one of the leading sweet-corn canning states, nevertheless the canners realize that the corn borer would doubtless be a decidedly limiting factor in their industry and are demanding the enforcement of this quarantine to delay the coming of the borer as long as possible. They report that they had nearly 15,000 acres of sweet corn grown under contract last summer and that they packed approximately one million cases of sweet corn. They join the dairy interests in asking that there be no let-up in quarantine enforcement and in demanding an annual clean-up so long as it seems practicable.

Use of silo aids control.—Cornfield disposal surveys made by the department of intervals of several years have revealed that each year more and more of the corn is either being ensiled or shredded. At least it is taken off the fields and the fields plowed late in the fall. Because of an unusually long growing season in 1935, Wisconsin harvested one of its biggest corn crops in many years, and the silos that usually hold the crop could not take care of much more than half of it. The rest was allowed to ripen until the first heavy frosts and then shredded to be fed before starting on the ensilage. As a result of a survey made in late November, it was found that the majority of fields in counties bordering Lake Michigan had the stalks pretty well disposed of before winter set in. Those fields were drilled to barley and oats the following spring and because of the low cutting of the stubble, very little débris was left in the fields; this made clean-up in these counties feasible with little additional labor.

The department is well equipped with authority to carry out quarantine enforcement and clean-up measures against the corn borer, for the statute provides that "In dealing with this pest the department, in addition to the authority conferred upon it with reference to other insect pests, shall have power to require the treatment or destruction of any agricultural or horticultural product, whether in field, feed lot, storage or elsewhere, and any special type of plowing or other farm operation within any district for which a quarantine for the control of this pest is established.

"In case the person in charge of such products or land shall fail to comply with any such order within the time prescribed, after due notice to him, the department of agriculture may take the action so required and the expense thereof, or such portion of such expense as the department of agriculture may determine, shall be assessed, collected and enforced as provided in subsection (2) of section 96.38. Such portion of the amount so assessed, collected and enforced against the owner of such premises, shall represent expenditures thereon by the United States,in carrying out the cooperative control measures hereby authorized, shall, on certification by the secretary of agriculture of the United States and approval of the commissioner of agriculture, be paid to the United States. In event the owner fails to comply with the department's order the law provides that the control work shall be done by the department and the cost assessed against the property owner.

"If such person does comply with said order, he shall be reimbursed by the state for the expense of the necessary farm clean-up measures required by the commissioner of agriculture which in the judgment of such commissioner are additional to those normal and usual in farm operations, and for which he has not been or will not be compensated by the United States. The statute provides further that the commissioner of agriculture shall adopt and enforce regulations defining what expenses shall be regarded as being additional to those usual and normal in farm operation, the manner in which claims shall be filled and the proof required."—9-10-36.

RECENT DEVELOPMENTS IN REGARD TO ALFALFA WEEVIL

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Recent discussions of the alfalfa weevil, *Hypera postica* Gyll., have emphasized the fact that this insect is important as the subject of quarantines rather than as a destructive pest. In fact, very little attention is now being given in entomological literature or conferences to life history studies or control methods, presumably because very little damage is being caused by the weevil and because satisfactory methods of control have been developed during the years it has been known to occur in the United States. Also, the effects of climatic conditions on the insect and the means of dissemination, both natural and artificial, have been ex-

tensively studied and the results of these studies have been summarized and interpreted by both state and federal entomologists. Their findings have, in general, agreed that the alfalfa weevil quarantines are not justified by the known facts.

Although the existing quarantines have been modified from time to time they are still being rigidly maintained and several states have recently issued alfalfa weevil quarantines for the first time. One of these new quarantines includes alfalfa seed among the regulated commodities, in spite of the fact that it was determined many years ago that live weevils do not occur in alfalfa seed.

It is not the purpose of this paper to present any new material but rather to call attention to some of the more important published information which might help the members of the plant boards to reach an understanding of the subject that will lead to sound and uniform quarantine action.

Alfalfa weevil as a pest.—One of the recognized principles of plant quarantine is that the pest concerned must be of such nature as to offer actual or expected threat to substantial interests. To be sure, it has been demonstrated that the alfalfa weevil can be and has been seriously destructive to alfalfa under certain conditions. On the other hand, there is much evidence to show that there are many situations and conditions under which the alfalfa weevil cannot maintain itself in destructive numbers even though those situations and conditions are favorable for the production of alfalfa, its principal food plant.

Essig & Michelbacher (*2*) after quoting various Old World authors conclude: "As a matter of fact, European and Asiatic entomological literature does not at all emphasize the importance of this insect as a pest of great or even ordinary economic importance." Also, they state that "weather conditions greatly influence the activity of the alfalfa weevil. Data obtained from various investigations seem to show that climatic conditions largely determine the destructiveness of the pest."

Michelbacher & Essig (*4*) in a later publication (1935) concerning alfalfa weevil in California, state: "Observations to date seem to indicate clearly that the weevil will not become a major pest over most of the alfalfa-growing region of the state." And they further state that "of all the factors which influence the weevil, and limit its destructiveness, climate appears to be the most important."

Reeves (*5*) reports that "within the limits of its present territory it occurs wherever alfalfa is grown, regardless of altitude and local climate. As a serious pest, however, it seems to be confined to the lower valleys in this region, presumably because of their warmer climate. It is noticeable also that even there it has reached great destructiveness only in the warmer seasons."

Sweetman (*6*) noted that "the alfalfa weevil has lost ground on the eastern front of the infested territory of Wyoming in the last two years. It was found at Torrington in 1926 and 1927 and at Manville in 1927, but these infestations have apparently disappeared, as scouting work in 1928 and 1929 failed to reveal its presence. While it is impossible at the present stage of these investigations to account for the disappearance,

a climographic study of the two places shows that the winter of 1927 was extremely dry and December temperatures were below the average. The weevil has failed to overwinter under outdoor conditions at Laramie where the winters are normally dry."

Cook's theory.—The conclusions quoted above strengthen the theory of Cook (*1*) who, according to Essig & Michelbacher (*2*) "after a careful review of the literature and a study of the conditions under which the insect occurs in its original home, states:

> In the case of the alfalfa weevil the limiting periods are two in number—the temperature limit, which applies largely to the hibernating adults, and the humidity limit, which applies to the larva and its fungus enemies.
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> * * * * * * * *
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> Broadly speaking, the alfalfa weevil is limited on the north, inside the Pacific and sub-Pacific rainfall regions, by low summer temperatures; on the east, at the edge of the sub-Pacific type, by heavy summer rainfall; and on the northeast, in the plains of Montana and Wyoming, by the summer rainfall and by low winter temperatures, plus a very light snowfall. No data have been found upon which to base a limit on the south, but it is possible that the high temperatures of southern California and Arizona may prove fatal to larvae.
>
> He further divided the region over which the pest might occur into three zones: (1) The areas of normal occurrence where climatic conditions are most favorable to the insect development, (2) regions whose normal climate departs slightly from the optimum, and (3) areas whose normal climate varies widely from the optimum, and in which favorable conditions rarely occur. In this latter area he states that the weevil will probably not be able to maintain itself, but may be repeatedly introduced and become of minor importance after a series of favorable seasons. According to Cook's investigations the alfalfa weevil is fast reaching the outer zone over which it might occur."

Damage in California.—Reporting on alfalfa weevil damage in California, Michelbacher & Essig (*4*) state: "Although the pest was established in many alfalfa fields throughout the infested area, so far as we have been able to ascertain there were never any complaints of its doing damage. True enough, in several places farmers probably observed some injury, but they never became alarmed enough to report it. Apparently the main reason for the weevil going unnoticed is that there are other alfalfa pests which cause much more damage. Among these are the pea aphis, alfalfa caterpillar, and the yellow-striped armyworm." Further, "our investigation points to the fact that in the hot, dry valleys of the state the alfalfa weevil is not likely to be a serious pest. The damage which it does compared with that of such insects as pea aphids, alfalfa caterpillars, yellow-striped armyworms, and grasshoppers, amounts almost to nothing."

In view of these careful studies conducted by many investigators under varied conditions it is difficult to understand why anyone should be so seriously alarmed about the spread of the alfalfa weevil as to insist upon the maintenance of such drastic, costly and disturbing measures as the state quarantines.

Control methods.—Those who in view of the authoritative expressions just quoted still fear the alfalfa weevil as a pest should be reassured

by the fact that, in the event the insect should become established and increase to such an extent in new territory that control measures might be needed, several very practical and inexpensive remedies have been developed and would be available.

Reeves (*5*) states that "the weevil is readily controlled by the methods described in this bulletin."

Timely alfalfa cutting controls weevil.—Although spraying and dusting with arsenicals are practical control methods, timely cutting of the alfalfa is most effective and has the added advantage of increasing the quality and quantity of hay.

As early as 1918 Hagan (*3*) pointed out "that many farmers in the infested area are cutting more hay than before the appearance of the pest owing to the adoption of better cultural methods."

Wicks (*8*) similarly states that "late cutting and growing of alfalfa seed increased the damage done by this pest. In Utah, which has been longest infested, cutting dates have been advanced, enabling growers to secure four good cuttings of hay as compared with previous conditions where they received only three cuttings of poor quality hay. In fact, it appears that the existence of the alfalfa weevil is doing more good than harm in regions where hay growers use the latest methods of cutting."

Quarantines.—Even though the alfalfa weevil had been proved a dangerous pest and no control methods had been developed, there is doubt in the minds of many entomologists as to the value of the alfalfa weevil quarantines in preventing the spread of the insect.

Dr. Claude Wakeland (*7*) of Idaho, in a paper given at the last annual meeting of the Central Plant Board, quoted A. J. Cook, commissioner of horticulture of California, as saying in 1911 in regard to transportation of the alfalfa weevil by the railroads: "We cannot quarantine against it. . . . From the nature of the case—there is no possible, sure way to prevent such invasions." In 1912, he added, "you can hardly, by the strictest quarantine possible, keep it from our alfalfa fields, as it is quick to take passage even in Pullman cars."

Dr. Wakeland also quoted another California official as saying, "A quarantine to be effective would practically prohibit the movement of cattle, freight and passenger cars from or through the territory." In commenting on Dr. Cook's statement as quoted above, Dr. Wakeland says that "Dr. A. J. Cook's opinion of the effectiveness of quarantining for alfalfa weevil could more validly be expressed today than in 1911—the chief difference being that such an opinion today has the added weight of the failure of quarantines rigidly enforced to prevent long distance jumps of the insect."

Reeves (*5*) states: "It has thus far been impossible to prevent the diffusion of the alfalfa weevil by regulating the production and marketing of alfalfa."

Wicks (*8*) points out that "probably the greatest weakness in all alfalfa weevil quarantine regulations is that not enough attention is paid to all other possible means of distributing the weevil." He also states that "quarantines appear to be inefficient, and unfortunately they have shown many discrepancies which have only tended to interfere with

normal movement of produce, and have been instrumental in arousing public sentiment against quarantines in general. The majority of quarantine officials of this (Western Plant Quarantine Board) board have expressed their opinion that the economic importance of the alfalfa weevil is overestimated and that quarantines should be revised on a scientific basis or abandoned."

That the Western Plant Quarantine Board is still interested in revising the quarantines is indicated by the following resolutions adopted at their last annual meeting:

VII

ALFALFA WEEVIL DISSEMINATION

WHEREAS, No reliable facts are now available concerning the dissemination of alfalfa weevil through the medium of baled alfalfa hay, baled and shipped during the winter months, therefore,

BE IT RESOLVED, By the Western Plant Quarantine Board assembled in regular session at Sacramento, May 21–23, 1935, that the United States Bureau of Entomology and Plant Quarantine be respectuflly requested to investigate and determine as soon as possible, the possibility of live alfalfa weevil being carried in baled alfalfa hay when same is shipped from known infested areas during the dormant season, with the expectation that if it so be demonstrated by this investigation that there is no additional danger in this regard, that all states enforcing alfalfa weevil quarantines will immediately modify same accordingly, the expense of such investigation to be met, if necessary, by the use of Federal emergency or relief funds.

VIII

ALFALFA WEEVIL SURVEY

WHEREAS, Authentic knowledge of the distribution of the alfalfa weevil in the United States is not now available,

THEREFORE BE IT RESOLVED, By the Western Plant Quarantine Board, assembled in convention at Sacramento, California, May 21–23, 1935, that the United States Bureau of Entomology and Plant Quarantine be respectfully requested to make an early and thorough survey of all alfalfa-producing areas in the United States to determine the present extent of the alfalfa weevil infestation, the expense of such investigation to be met, if necessary, by the use of Federal emergency relief funds.

Conclusion.—The existing quarantines place an embargo upon the movement of "alfalfa hay, other hay and cereal straw" from all of the areas infested by the alfalfa weevil. There seems to be a great range of opinion among different entomologists and different states as to just what risk is embodied in the movement of these materials from infested to uninfested areas. Some think the risk is very great, others that it is unimportant. Data, based upon carefully planned and executed experiments and observations to determine the facts in this matter, are practically wanting. Results of such experiments made by an infested and quarantined state would not likely be accepted by other uninfested states as constituting an unbiased answer to the questions involved. Uninfested states naturally could not make such studies. Only the results of a thorough study of this question by the federal Bureau of Entomology and Plant Quarantine would receive universal respect and acceptance. It seems, therefore, that the indecision and the varied attitudes of the

states, and the lack of data upon which they could reach a common and reliable understanding, make it mandatory that the Bureau of Entomology and Plant Quarantine should undertake to secure the needed information. As the quarantines are extended in scope with the constant finding of new infested areas, the urgency of this matter increases, and the losses to hay producers, dealers, transportation agencies and consumers, through the dislocation of normal commercial traffic, also are constantly increased.

Not only is information needed as to the danger of the transportation of the weevil in "alfalfa hay, other hay and cereal straw" as a group, but information is needed as between these commodities. If investigation should prove a real danger in the transportation of alfalfa hay from infested to uninfested areas, does that necessarily signify that danger also attends the transportation of prairie hay from infested to uninfested districts? Or of cereal straw? No body of information on this subject seems to be available, and yet quarantines, involving a vast disturbance of commerce and attendant heavy losses, are based on the pure assumption that such serious danger does exist. And if there is danger in the transportation of any or all of these materials at one time of the year, does that indicate that the same danger exists at all other times of the year? An accurate answer is needed to this question also.

At the recent hearing on the intrastate quarantine on Sioux and Scotts Bluff counties in Nebraska, held August 5, 1935, the question was quite appropriately brought up as to what effort had been made to learn whether the alfalfa weevil did or did not occur in the states to the east of the Missouri and Mississippi rivers. It is assumed that it does not occur there but no one can cite any definite effort to make fairly sure that such is the case. It seems that there should be a survey, not only in the borderland of the known infestation in Wyoming, Nebraska and Colorado, but also in areas farther east.

It appears important that the Bureau of Entomology and Plant Quarantine should assume a position of leadership in the matter of securing the scientific data upon which entomologists could come to an agreement as to whether or not a quarantine is desirable and worth while, and if it is, upon what areas, and in what seasons of the year.

The interests of all of the nine infested states demand the settling upon a scientific basis of this evaded, much confused and poorly understood situation, and the Bureau of Entomology and Plant Quarantine should be given a substantial appropriation by Congress to finance the research work, surveys and other investigations that would be necessary to secure a sound settlement of this problem, with the minimum necessary restrictions on the movement of commodities from infested to uninfested areas. —9-9-36.

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STRAWBERRY PLANT CERTIFICATION WORK IN MINNESOTA

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As we continue our strawberry plant certification work in Minnesota we realize more and more that adequate inspection (plant-to-plant field inspection) is the only means by which we can guarantee the stock to be free from the several serious diseases and insects now known. It is without question the only practicable means by which we can be assured we are using clean stock in our own commercial plantings, and shipping clean stock to other states. Up to the beginning of our special certification work two years ago we found considerable disease in our own stock and no doubt our out-of-state shipments contained diseases, particularly some of the virus diseases of unknown causative agents. I do not see how other states, where the nematode is a major pest, can profitably produce fruit without obtaining clean stock and certainly clean stock cannot be taken continually from uninspected plantings without sooner or later destroying that industry. If the acreage is too large to inspect, or where it seems impractical to inspect large plantings, at least out-of-state shipments should be given plant-to-plant inspection. In other words, the shipments going out of the state should come from plantings where real plant inspection has been made and where the plants have been found apparently free from all degeneration diseases and other dangerous diseases and insects.

Our certified acreage in Minnesota in 1935 was 215 acres (63 varieties) but of course had we followed the old or usual standards for passing plantings the acreage might well have been three or four times this figure.

The principal troubles seem to come from plant diseases, so that leading horticulturists and plant pathologists throughout the country realize the importance of thorough inspection for strawberry plants for these diseases as well as for the insects. Hendrickson (*4*) of California states, "Plants from diseased or insect-infested areas should be discarded and only healthy ones chosen. Carelessness in the choice of plants often leads to the introduction of diseases and insects into sections that may previously have been clean."

Stevens & Mook (*8*) on strawberry dwarf, state, "Whether dwarf will

ever become important in the northern states is of course an unanswerable question, but at present it is surely a southern problem and our experience to date makes it appear safe to say that in regard to yield, the disease is of greatest economic importance in the south and decreases in severity as we go northward. On the other hand, nurseries either in the north or in the south which expect to supply southern growers with strawberry plants will find it necessary to use every precaution to keep their plantings free from this disease as the wise southern growers simply will not continue to buy plants from dwarf-infected nurseries."

So far as we know, we do not have the strawberry dwarf or nematode in Minnesota but of course are always on the lookout for it. Knowing that we do not have the nematode of strawberries in Minnesota and with our present knowledge of strawberry plant storage, we feel that southern growers in nematode-infested areas greatly benefit by obtaining northern-grown stock. These special certification methods and the fact that we can store plants during the winter months for early spring or winter shipments to southern states have developed our program considerably since its inauguration.

Stevens & Mook (*8*) also say, "It is our honest opinion, made from field observations and acquaintance with the disease (dwarf), that adequate nursery inspection and *careful certification* offer the simplest, most direct and most promising line of attack."

Another strong statement along this line made by these men: "We would like to go one step further and state our belief that the whole strawberry industry would benefit from a rigid system of nursery inspection. It is pointed out that fruit trees are sold chiefly to big growers and last from 20 to 40 years, but many strawberry growers, big and little, buy plants almost every year. Our opportunity for effective disease control is correspondingly increased."

According to A. G. Plakidas (*6*) the two most serious diseases of strawberries in Louisiana seem to be the two leaf blights, the leaf spot, *Micosphaerella fragariae*, and scorch, *Diplocarpon earliana*. Leaf spot is extremely destructive in northern plantings. We do not certify plantings heavily infected with leaf spot. In fact, plantings are not certified if more than a trace of leaf spot is found.

Zeller (*9*) of Oregon, discussing crinkle disease of strawberries, states that after disease-free plants have been selected and these disease-free plants set out, "the following year this plant is rogued, removing immediately the whole plant unit whenever plant symptoms appear in any plants of that unit. Such a procedure, if very carefully pursued, should soon yield a high-grade foundation stock for certification for freedom from disease." This points definitely to the fact that roguing from plant to plant is the only means of eliminating this particular disease.

Stevens (*7*) of the U. S. Department of Agriculture, in discussing field observations on strawberry dwarf, states, "On the basis of present information one of the most promising lines of attack for increased control of the disease within the area where the disease occurs is *certification* of disease-free plantings." He also states that one of the control methods practiced in addition to roguing and planting on new land is the "pur-

chasing of plants from regions where the disease is not common." It is only through continued and careful inspection that we can guarantee that the disease is uncommon in our northern states.

R. E. Loree (*5*) in his bulletin states that "the plants should be secured from some reliable nurseryman who makes a specialty of growing good plants, or they may be taken from fruit plantations. Home-grown plants have some advantages and a commercial grower will often find it cheaper and more satisfactory to propagate his own plants than to purchase them from nurseries."

It is, of course, true that the immediate cost of new plants is considerably reduced by using home-grown stock. On the other hand, I find that serious diseases are being continually perpetuated in many of our commercial plantings where home-grown plants are used.

Brooks, Watson & Mowry (*1*) of Florida make the following statement: "By securing plants from northern sources each year, plant diseases and insects are held in check more readily than by carrying over Florida plants from year to year."

I believe that in time, if good roguing inspection is given to those who wish to produce certified stock, our growers will benefit much by obtaining such plants rather than using the home-grown plants.

As I stated in my last year's report on strawberry certification in Minnesota, our work is carried on very closely in connection with our Plant Pathology Division of the University of Minnesota and we have a plant pathologist on the job with us during the six summer months. We have found that without this special emphasis and study it is impossible to find and determine a good many of these damaging degeneration and virus diseases.

As a result of our strawberry plant-disease study in Minnesota in cooperation with Dr. Carl J. Eide of the University of Minnesota Plant Pathology Division, it was decided that we might tentatively classify degeneration diseases found in Minnesota into three types: (1) witches' broom, (2) a type of mottling which is probably the same as that found throughout the northeastern part of the United States—effect of mosaic; June yellows, the cause of which is not known, (3) a severe yellowing which cannot be tentatively identified with anything seen in the literature but which may be of the same type as classified under (2).

To proceed with a certification program for the control of these diseases in planting stock, it is of course necessary to know what causes the diseases, and particularly we must know whether the causes are of a contagious nature. We must know the symptoms at the different times of the year and the symptoms as they appear in the various varieties. If it is true, as stated by some specialists, that the trouble arises in hybrids, it will be necessary to see that great care is taken in propagation to keep the original varieties pure. Of course, it will require considerable more research work before we can arrive at any satisfactory conclusion concerning some of these troubles.

Our program, as set up with Dr. Eide of the Plant Pathology Division of the University of Minnesota, is made with the special emphasis of finding practical economic methods of diagnosis and control.—9-9-36.

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RECENT DEVELOPMENTS IN CONTROL OF GRAFT KNOTS ON NURSERY APPLE TREES[1]

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Graft knots on nursery trees grown from piece-root apple grafts may be practically eliminated. Formerly they caused so much difficulty that a symposium on the subject was called at the 1924 meeting of the American Association for the Advancement of Science. At this session it appeared that the various participants were unable to agree concerning the identity of various graft knots. They were likewise unable to decide upon uniform procedures to be applied by the inspection service. However, it was evident that the problem should be settled, not by opinion, but as the result of scientific investigation. Consequently, a research program was initiated in which there was cooperation between the Crop Protection Institute, Iowa State College, the National Association of Nurserymen and the University of Wisconsin. After several years the continuing investigation was conducted cooperatively by Iowa State College, the U. S. Department of Agriculture and the University of Wisconsin working with the various members of the National Association of Nurserymen. As the evidence accumulated it was made available in preliminary statements, but more recently the detailed results have been published. Meanwhile a considerable literature by other workers has appeared on the question, both in this country and abroad. Some 50 papers before 1934, from the cooperative and other investigations, have been considered and cited elsewhere (*2*).

From the very first, the easiest solution of the problem appeared to be prevention of the formation of graft knots. One method of control available was propagation by budding. However, at least the midwestern nurserymen did not care to employ it, for reasons beyond the scope of

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station. These pages are condensed from an invitation paper given December 30, 1935, before the Plant Quarantine and Inspection Section of the American Association of Economic Entomologists.

this paper. It was evident that the nursery trade did not wish to handle trees bearing graft knots when trees with smooth unions were available. The trade considered knotted trees in the same class with trees having "bobbed" roots, crooked or skinned stems, or broken tops, which should not be sold as first-class trees.

Consequently, the investigation took the direction of determining first, the cause of these graft knots; and second, the means for preventing them. Some of the results have been summarized in the following paragraphs.

Cause.—The nature of the several overgrowths, grouped together under the general term of graft knots, was determined after several years of study to be primarily threefold: (1) excess callus, caused by a wound which developed into a wound overgrowth; (2) crown gall caused by *Phytomonas tumefaciens* (Smith & Town.) Bergey *et al.;* and (3) infectious hairy root caused by *P. rhizogenes* R.B.W.K. & S. (Several other items, including "genetic" hairy root, woolly-aphis injury, and root knots caused by nematodes, are beyond the scope of this report.) The relative importance of these different types of graft knots varied greatly in the same season in different nurseries and in different seasons in the same nursery. Wound overgrowth and hairy root were particularly important on apple grafts, whereas crown gall was particularly important on peaches, raspberries and roses, and of a relatively minor consequence in most places on apple grafts. These three types of malformations are illustrated in figs. 1–5.

Wound overgrowth.—The nonparasitic graft knot, fig. 2, formed by excess callus, which grew and became a wound overgrowth, presented the least problem in relation to control measures. Here the primary requisite was to make grafts which were well fitted and wrapped with suitable material so that excess callus did not extrude from the surface. Practices which resulted in grafts with scions larger than roots or with scions having a long lower tip, which did not unite cambium to cambium with the root, were found to be disadvantageous. Likewise, the use of melted wax to cover the union, in a way which permitted the wax to flow between the scion and root, was found undesirable. Similar overgrowths may be induced by a wound on the scion, fig. 1.

Crown gall.—Crown gall, fig. 4, of relatively minor importance on apple grafts, was controlled by the same measures used against hairy root.

Hairy root.—Infectious hairy root, fig. 5, presented a somewhat more difficult problem than wound overgrowth. It was found that infection for the most part was carried into new plantings on the seedling roots and that after it had been introduced it was spread from infected plant to uninfected plants by root-chewing insects. This spread occurred not only during the first year but also during later years, particularly when fresh callus was available for insect feeding. Cultivation injuries were also important factors for the entrance of pathogenic bacteria. Fortunately for the success of control efforts, it appeared that well-made grafts which did not extrude excess callus were less liable to be visited by root-chewing insects and correspondingly less liable to become infected.

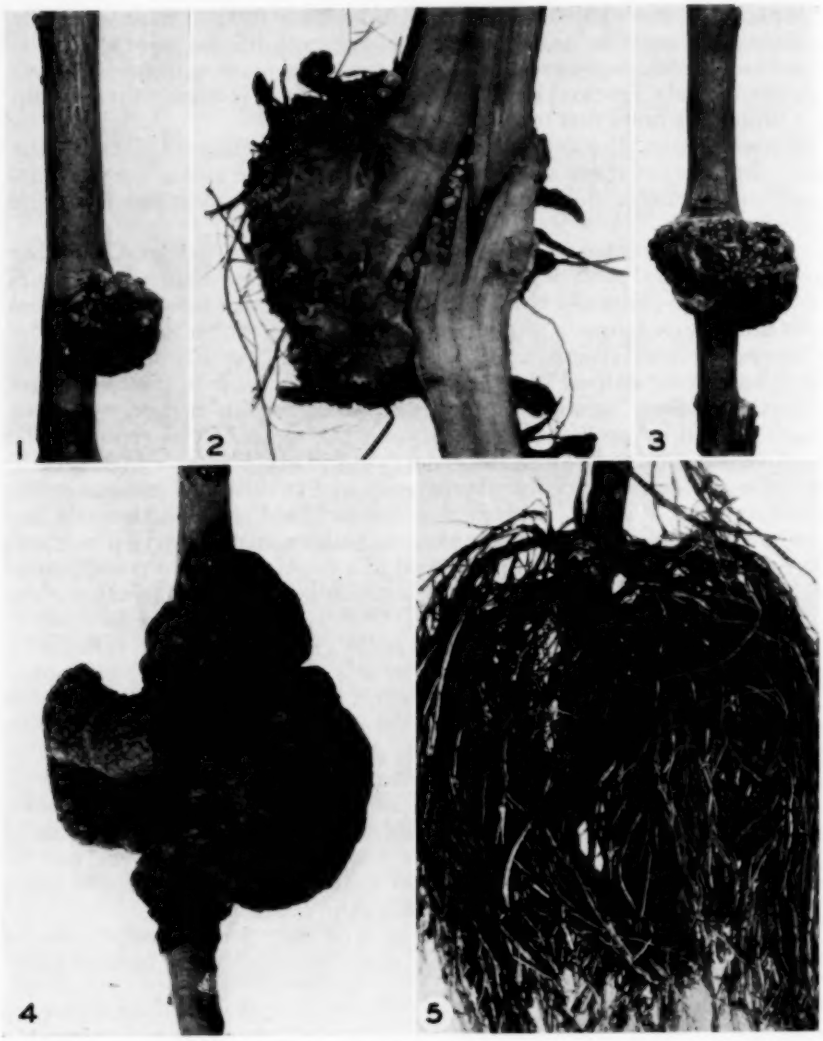

Fig. 1–5.—Several kinds of overgrowths on nursery apple trees. *Fig. 1.*—Wound overgrowth induced after 20 weeks by a cut above the union on the side of a one-year-old tree. *Fig. 2.*—Section through the union of a three-year-old tree showing the original badly fitted graft and the wound overgrowth that developed at the lower end of the scion. *Fig. 3.*—Wound overgrowth induced after 20 weeks by a wire girdle just above the union of a one-year-old tree. *Fig. 4.*—Crown gall 16 weeks after inoculation with *Phytomonas tumefaciens*. *Fig. 5.*—Hairy root 18 weeks after inoculation with *P. rhizogenes*.

Combinations.—Various combinations of these different kinds of overgrowth appeared frequently. When hairy root was prevalent on two

or three-year-old apple trees it was very commonly found in association with wound overgrowth. Sometimes the hairy root came first and the wound overgrowth developed in connection with it. At other times the wound overgrowth appeared first and became infected through mechanical or insect injuries.

Studies on control.—Procedures for commercial control were based on the above information and were tested during seven years of trials in representative nurseries from Wisconsin to Oklahoma. These procedures were: (1) removal of infected bacteria if they were abundant on the surface of the seedlings used in grafts; (2) preparation of well-fitted grafts from clean roots with a dry surface, so as to reduce the spread of bacteria over the cut; (3) use of wrappers which prevented excess callus and which protected the grafts from the attack of insects as long as possible but decayed before girdling the growing tree, fig. 3; and (4) choice of soil relatively free from insects.

Bacteria on the surface of seedling grafts, except in a few instances, were of relatively low concentration. In these exceptional cases the seedling roots could be washed in water until the soil was removed and then dipped for one minute in corrosive sublimate, 1:1000. They were stored, without rinsing, in clean sawdust for a week before using. However, in most cases the relatively few bacteria on the surface were destroyed by a wrapper of nurseryman's adhesive tape (*1*) which contained mercuric chloride 1:300 by weight.

Wrapper.—This tape wrapper, which was the best of various wrappers employed, was applied on the well-made commercial piece-root graft in a spiral with a very small overlap so as entirely to cover the union. When thus covered excess callus was avoided. For (1) economy of material, and (2) prevention of girdling, it was essential to use only enough tape to accomplish this purpose. The wrapper was prepared so that ordinarily it would protect the union for at least several months while gradually diminishing in tensile strength. The time varied according to several factors but especially according to the moisture in the soil. If the soil was deficient in moisture the wrapper lasted longer but the trees grew more slowly in diameter. The wrapper might appear to be intact when its tensile strength was reduced practically to zero. This condition, when grafts have failed for some other reason, has occasionally caused some nursery men wrongfully to suspect that the tape was too heavy. Determination of whether the tape was too heavy was made by observing whether it lasted long enough to induce girdling, fig. 3. Antiseptic solutions should never be applied to tape wrappers because they prevent suitable decay of the cloth. If the tape decayed too quickly, protection from the formation of excess callus and from the attack of root-chewing insects was correspondingly reduced.

Root-chewing insects in the soil were a sufficiently important consideration to require care in the selection of ground for planting apple grafts. Land like old pasture, which might be heavily infested with such insects, is to be avoided.

Whenever these various precautions were rigidly observed commercial control of graft knots was secured in the middle west.—9-1-36.

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STATUS OF THE ALFALFA SNOUT BEETLE IN NEW YORK

BRACHYRHINUS LIGUSTICI L.

CHARLES E. PALM, *Cornell University, Ithaca, N. Y.*

Study of the alfalfa snout beetle problem in northern New York[1] has been continued during the season of 1935. The emergence of this insect and its migration habits were observed for the first time in North America. Experimental measures were begun for the control of this pest in addition to further studies on the biology, wild host plants and possible ways by which it might be spread.

Present known distribution.—The Bureau of Plant Industry of the New York State Department of Agriculture and Markets, under the direction of Dr. A. B. Buchholz, conducted spring and fall scouting surveys in the alfalfa belt adjoining Oswego and Jefferson counties. In neither of the two surveys were infestations of *B. ligustici* found outside of these counties. Additional injury was discovered in Jefferson county which would seem to indicate a slow spread of this insect within the known limits of distribution. A total of 592 acres of land in Oswego and Jefferson counties are now known to be infested. Because of the difficulty in locating light infestations the rate of spread into the alfalfa belt is still uncertain.

Emergence and migration.—The beetles began to work their way toward the surface from their resting cells in the soil late in March and early in April. The first beetles appeared on the surface April 11, but remained beneath débris until April 21, when weather conditions became favorable for movement. The peak of migration was reached about May 8–10, and diminished rapidly, although a few beetles were moving as late as June 10. During cold rainy days the adults clustered beneath stones, in clumps of grass or under clods of dirt and remained there until the temperature favored activity. Practically all migration took place during daylight hours.

The adults fed voraciously on the foliage of a number of host plants. Feeding was most pronounced on alfalfa and clover during the first two weeks after emergence, although it continued on through the egg-laying

[1] This work was conducted under the direction of Professor P. W. Claassen. From May 1 until June 9, Elmer W. Beck of the U. S. Bureau of Entomology and Plant Quarantine cooperated in various phases of the work and assisted on the problem wherever possible. Credit is due C. G. Lincoln and C. P. Zorsch who rendered valuable services during a part of the work.

period. The beetles fed on any part of the tender short growth; much of the feeding, however, was confined to the basal parts. After feeding, egg development commenced and migration slowed down. Once oviposition began there was practically no lateral migration except a secondary phase which came after the first cutting of hay.

In his dispersion experiments Mr. Beck liberated a total of 2989 marked beetles at the sides of a plowed field near a long trench barrier. Eleven of the recovered beetles had traveled over plowed ground and were caught in barriers 677 and 690 feet from the point of liberation. Four beetles traveled 677 feet in 7, 8, 10 and 11 days respectively, and seven crawled a distance of 690 feet, one in 10 days, four in 11 days, and two in 14 days. It is not known how far they will migrate through alfalfa.

Oviposition.—Oviposition was first noted in the field on May 20. The last egg deposited by a beetle collected in the field was on September 8. Under insectary conditions egg deposition began May 21 and continued until July 31. A small series of beetles which were not given food deposited no eggs. A few adults that were given orchard grass and timothy, although they fed lightly, likewise failed to oviposit.

Pupation.—Pupation began June 18. The first pupae came from an area in the better drained part of the field. In this same area, pupation was complete by July 18; transformation to adults began on July 10. In another part of the same field, in heavy wet soil, the first pupae were obtained on July 15 and the last on September 3. Variation in soil temperature affects the rate of pupation.

Host plants of the larvae.—Out of thirty-six different host plants which thus far have been used, larvae are being reared on the following: alfalfa, *Medicago sativa* L.; dock, *Rumex obtusifolius* L.; cinquefoil, *Potentilla recta* L.; yarrow, *Achillea Millefolium* L.; quack grass, *Agropyron repens* (L.) Beauv.; alsike clover, *Trifolium hybridum* L.; wild strawberry, *Fragaria virginiana* Duchesne; blackberry, *Rubus* sp.; red clover, *Trifolium pratense* L.; plantain, *Plantago major* L.; sorrel, *Rumex Acetosella* L.; cabbage, *Brassica oleracea* L.; and chicory, *Cichorium Intybus* L. Larvae of the 1935 brood that were collected on August 15 and placed on new hosts are developing on plants other than those mentioned, including goldenrod, *Solidago* sp.; red raspberry, *Rubus idaeus* L.; shepherd's purse, *Capsella Bursa-pastoris* (L.) Medic.; white clover, *Trifolium repens* L.; black locust, *Robinia Pseudo-Acacia* L.; yellow sweet clover, *Melilotus officinalis* (L.) Lam.; white sweet clover, *Melilotus alba* Desr.; winter cress, *Barbarea vulgaris* R. Br.; Canada thistle, *Cirsium arvense* (L.) Scop.; corn, *Zea mays* L.; and dogwood, *Cornus stolonifera* Michx.

A certain number of the larvae do not complete their development the first year. From July 17 until August 14, partly mature larvae of the 1934 brood were collected from the field and placed on 15 different host plants. A total of 83 larvae were collected. On October 31, 29 larvae were still alive; five had pupated and transformed to adults. One had completed its feeding on soybeans, two on quack grass, one on mullein, and one on dock. Since a few of the grubs require two years to complete

their development, it seems almost certain that these individuals will have a three-year life cycle.

Seasonal history.—The two-year life cycle of *B. ligustici* has been verified under experimental conditions. Larvae that hatched from eggs deposited in the summer of 1934 finished their feeding on alfalfa by December of 1934, pupated in June and July of 1935, transformed into adults and remained in hibernation in the rearing containers. One adult has been reared on dock, *Rumex obtusifolius*, as the larval host. Apparently dock is equally as satisfactory as alfalfa for food of the larvae and adults.

Spread.—The distribution of the alfalfa snout beetle is limited to an area of New York state where the acreage of alfalfa and clover is small. All of the hay grown in this region is used or sold locally; none is exported. *B. ligustici* is not yet known to occur in the main alfalfa belt of the state.

In connection with the study of the habits of the adults it has been found that some of the beetles collect under newly cut hay in the field and a few are carried with it into the barns. These adults quickly leave the unloaded hay in search of growing plants and more favorable temperature conditions. The only possible danger of spread through the medium of hay seems to be local, that is, from farm to farm where the crop is bought on the lot and is removed at cutting time.

The wingless condition of the adults makes the natural rate of spread very slow. There is some feeling that beetles which get into streams at the time of migration may be carried by water currents. A far greater danger of spread can be expected from migrating beetles which may crawl into vehicles along roadways and be transported into uninfested areas. Because of the parthenogenetic reproduction of this species an isolated beetle may start a new area of infestation.

Control.—Most of the control measures in 1935 were directed toward the adults during their preoviposition period. In the experimental work the following objectives were kept in mind, to determine: (1) the use of barriers to prevent spread from infested fields as well as to protect new seedings within the infested area, (2) the value of poisoned baits in infested alfalfa and clover fields and on plowed fields in which the beetles were emerging, (3) the use of sprays and dusts on the foliage of alfalfa and clover to kill the beetles, (4) the effect of cultural practices upon the control of this insect, and (5) crops suitable to use in rotations following the plowing up of an infested alfalfa field.

Most of the field experiments were conducted on one-eightieth-acre plots although a small series of one-twentieth and one-three-hundredth-acre size were used. The majority of the plots were surrounded with a strip of crude chipped napthalene, 3 to 4 inches wide, to prevent cross-migration. Unfortunately this arrangement did not prove entirely satisfactory because the population of the plots shifted to the periphery and in some instances crowded across the barrier. At other times most of the beetles collected in the corners and did not feed normally; in one series of plots the emergence was very light.

A unit area of 1 square foot of surface was used in making counts,

with the exception of one series of bait plots. In this case 300 beetles were counted at random from each plot.

The data must be considered as preliminary and as suggestive of a trend to be followed in control experiments of the coming year. It is realized also that the materials tested must be used again under more optimum conditions before any conclusions are drawn.

Table 1.—Baits for the alfalfa snout beetle.

Bait Treatment	Replications	No. Beetles Alive	No. Beetles Dead	Per Cent Kill
		A		
Raisin–shorts–sodium fluosilicate	Plot 1	12	288	96.
	Plot 2	49	251	83.7
Alfalfa–meal–molasses–Paris green	Plot 1	251	49	16.3
	Plot 2	254	46	15.3
Bran–molasses–Paris green	Plot 1	287	13	4.3
	Plot 2	291	9	3.
Apple pomace–calcium arsenate	Plot 1	295	5	1.7
	Plot 2	286	14	4.7
		B		
Raisin–shorts–sodium fluosilicate	Plot 1	12	352	96.7
	Plot 2	5	243	97.9
	Plot 3	4	320	98.8
Apple pomace–molasses–sodium fluosilicate	Plot 1	158	491	75.7
Apple pomace–brown sugar–sodium fluosilicate	Plot 1	199	105	65.5
	Plot 2	185	340	64.8
	Plot 3	213	397	65.1
Alfalfa meal–molasses–Paris green	Plot 1	136	32	19.1
	Plot 2	85	127	59.9
		C		
Raisin–shorts–sodium fluosilicate	Plot 1	13	108	89.3
	Plot 2	4	91	92.6
Apple pomace–molasses–sodium fluosilicate	Plot 1	18	12	39.
	Plot 2	18	11	37.9
		D		
Raisin–shorts–sodium fluosilicate, on plowed ground	Plot 1	18	188	91.2
Raisin–shorts–sodium fluosilicate, in alfalfa	Plot 1 (5/15)	72	263	78.5
	Plot 1 (6/3)	4	396	98.9

A.—Treatments made on one-eightieth-acre plots on plowed ground surrounded with naphthalene barrier. All applications made April 25 and a total of 300 beetles was counted from each plot, April 27, 1935. B.—Treatments made on one-eightieth-acre plots on plowed ground surrounded with naphthalene barrier. All applications made May 5–6, except the apple pomace–molasses–sodium fluosilicate bait, which was applied May 8. Thirty-two counts of 1 square foot area were made in each plot May 13–14, 1935. C.—Treatments made on one-eightieth-acre plots in alfalfa surrounded with naphthalene barrier. Applications made May 8; 32 counts of 1 square foot area were made in each plot May 17, 1935. D.—Treatments made on one-twentieth-acre plots surrounded with naphthalene barrier May 11, 1935. Counts for the plowed-ground plots were taken May 14–15 and for the alfalfa plots May 15–16 and June 3.

Barriers.—A straight-walled trench barrier, 8 to 12 inches deep, depending on the type of soil and depth to which the grass roots penetrate, was probably the most economical and effective barrier used. Post holes at 15 to 25-foot intervals in the bottom of the trench collected the beetles. A trench barrier worked best when the side walls were dry and free from grass roots. During rainy weather the trench walls became wet and packed down so that the beetles crawled up the sides and escaped.

In order of their effectiveness, the following repellent barrier materials

were used: crude chipped naphthalene, creosote, drained motor oil with crude chipped naphthalene in suspension (2 pounds per gallon), pine tar, and coarsely ground flowers of sulfur. These materials were laid on the surface of the ground as strip barriers. None of these repellents prevented migration when large numbers of beetles assembled along them. They worked best with trap holes on the front side of the barrier to collect the beetles that migrated along it.

Baits.—The raisin–shorts–sodium fluosilicate bait, which was developed by Downes (*1*) for the control of the strawberry root weevil in British Columbia, proved to be the most effective bait used, table 1. Both in growing alfalfa and on plowed fields from which beetles were emerging, this raisin–shorts bait gave excellent kill. The minimum effective dosage of the material per acre has not been determined. In the work of the 1935 season the bait was used at the rate of 100 pounds per acre, which is more than necessary, particularly on plowed fields.

Apple pomace soaked in a solution of molasses, water, malt syrup and yeast, was substituted for raisins. The apple pomace–shorts bait was effective for a short time, but soon dried out and lost its attractiveness. Mineral and vegetable oil added at the rate of 1 gallon per 100 pounds of bait helped to retain the moisture but acted as a repellent to the beetles. Bran–molasses–Paris green bait, apple pomace–calcium arsenate, and alfalfa meal–molasses–Paris green bait dried out too quickly to be of any value.

Sprays.—Of the different spray materials used, calcium arsenate at 2½ pounds to 50 gallons of water with 2½ pounds of hydrated lime and 1 pound of soap gave the best results. It seems as if the efficiency of a spray depends on thorough coverage of the basal part of the alfalfa shoots as well as the foliage. Other materials tested include lead arsenate, zinc arsenite and natural cryolite.

Dusts.—Dusts of calcium arsenate and hydrated lime in equal parts, and calcium arsenate and finely ground dusting sulfur in equal parts gave very encouraging results. In addition to these materials, 1 per cent rotenone, synthetic cryolite, and barium fluosilicate were tested. Dusts, like sprays, must cover the basal shoot growth as well as the tops in order to be effective.

Cultural methods.—Observations in the spring of 1935 show that infested alfalfa fields that were plowed in the fall and harrowed before the middle of April contained practically no living vegetation on the surface. Beetles emerging from these areas were forced to migrate out to feed. Because of this fact, poisoned baits were particularly effective when broadcast over the surface of the field. In contrast, fields that were plowed in April contained scattered vegetation at the time of emergence and afforded shelter and food for some of the beetles.

Corn is a safe crop to plant after the plowing of infested alfalfa. Quite likely soybeans may be sown the second year if desired.

Summary.—Control measures for *Brachyrhinus ligustici* L. in the Oswego area of New York should be carried on during late April and the first half of May. Beetles appeared on the surface on April 11 and began active migration April 21.

For clean-up measures, a badly infested field should be plowed in the fall, harrowed or disced as early in April as possible and dragged. This treatment forces migration of the beetles when they emerge and affords ample opportunity to employ effectively poison baits and barriers.

The raisin–shorts bait gave good experimental control of the adults both in seedings of alfalfa and on plowed ground. The attractiveness of poisoned bait depends, it seems, on the bait remaining moist and sweet.

Sprays and dusts of calcium arsenate on the alfalfa and clover foliage gave encouraging results.

The effectiveness of trench barriers depends on the side walls being dry and free from grass roots. With any type of barrier, trap holes or bait greatly increase the efficiency by taking the beetles out of circulation.

Oviposition was first noted on May 20. The last egg deposited by a beetle collected in the field was on September 8.

There is evidence that under certain conditions *B. ligustici* will have a three-year life cycle.

Beetles may be carried into the barn with freshly cut hay, although they tend to leave the hay as quickly as possible. The greatest danger of spreading this insect comes at the time of the spring migration when adults may crawl into some vehicle and be carried.

Since the preliminary survey in 1934, no new infestations of the alfalfa snout beetle have been found outside Oswego and Jefferson counties. Additional infestations have been found within these areas, some of which were overlooked in the preliminary survey.—9-4-36.

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COTTON STATES BRANCH

PAPER-READING SESSION, ELEVENTH ANNUAL MEETING

Jackson, Miss., February 1936

CHALLENGE OF THE ARGENTINE ANT

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Selection of a subject for a chairman's address is not easy. A review of entomological literature will show that almost any topic that may occur to you has already been fully discussed by somebody else. Much has already been written about the problem I shall present to you, but because I believe it is not receiving from entomologists the attention it merits, I ask your serious consideration of the Argentine ant in relation to the future of the South.

Twenty-eight years ago, at the annual meeting of the American Association of Economic Entomologists, Dr. Wilmon Newell, confronted with this pest in Louisiana, stated that he believed the Argentine ant problem

would rank in magnitude along with the San Jose scale, gypsy moth and the boll weevil.[1] Whether Dr. Newell still holds that opinion, after years of residence in Florida, which is practically free of Argentine ants, I do not know, but our experience with this pest in Mississippi causes us to nominate Dr. Newell for a very high rank among the major prophets. Certainly, in proportion to the areas infested, we receive many, many times more complaints of Argentine ants than of either San Jose scale or the boll weevil.

In spite of the unusually cold weather this winter, we received a letter two weeks ago from a county agent stating that ants were "almost making life unbearable" in his home. There is no denying that they cause untold loss and trouble to housewives, as well as to grocers, druggists and other merchants. They greatly increase the hazards of farm poultry raising by attacking sitting hens and killing hatching chicks. They make beekeeping very difficult and often drive colonies from their hives. Negroes in some of the badly infested towns in Mississippi, long since accustomed to eating ants in all their food, seek partial relief while sleeping by stuffing cotton in their ears. Sleeping children with cuts or sores on their bodies suffer especially from their attacks. The possibility ofspreading typhoid fever or other disease is indicated by their attendance on human feces in outdoor privies. Their protection of mealybugs, aphids and scale insects by the destruction of immature stages of predators is well known. In Louisiana, T. F. McGehee found that sugar cane fields infested with Argentine ants were so overrun with the sugar cane mealybug that the infested fields could be detected while driving along the highway, while the mealybugs were difficult to find in fields where the ants were not present.

These types of damage are familiar to most of you, but I mention them to refresh our memories for within the last four years at a meeting of the Southern Plant Board an entomologist objected to a discussion of the Argentine ant on the ground that it was not an agricultural or horticultural pest.

Although these common types of damage are well known, we have no definite information about the effect of the Argentine ant on our native birds and mammals when woods and forests become solidly infested. That such a condition will eventually exist all over the South seems inevitable unless eradication measures are used, for each infested town serves as a center from which the ants are dispersed in the surrounding rural sections. Monroe county, Miss., is a good example. Undoubtedly the ants were first established at Aberdeen, the county seat, but 27 other infestations have since been found in the county. Whether a future solid infestation of the Argentine ant will upset the balance of nature or not, we are already paying such a heavy tax to this pest as to justify determined efforts at eradication. A few weeks ago I interviewed the druggists in the town of Crystal Springs regarding the amount of ant poison sold there and it was estimated that this town of less than 2000 people spent each year from $3000 to $4000 for ant poison. A druggist in Aberdeen told me that sales of ant poison from his store alone amounted to $300 a

[1] Jour. Econ. Ent. 1(1):21. Feb. 1908.

month. The citizens of the city of Jackson spend many thousands of dollars each year in individual efforts to control these pests. This tax we are now paying will be multiplied an hundredfold in the future if this pest is allowed to spread unhindered. And yet—it is quite possible for the South to avoid this financial handicap, for eradication of the Argentine ant is entirely practical. In Mississippi 281 infestations have been found and of this total 43 apparently have been eradicated. This was accomplished in most cases merely by repeating regular poisoning campaigns from year to year, but we are now convinced that the destruction of colonies by oiling, burning and other supplementary measures will greatly hasten extermination. Less than 1 per cent of the area of Mississippi is known to be infested, and since eradication has already been demonstrated as practical and feasible, I feel that future generations will justly condemn us if we do not do everything possible to exterminate this pest. The same statement applies to the entire South, for with the exception of Louisiana there are fewer infestations and the problem is perhaps less difficult in every other state than in Mississippi. In southern Louisiana there may be areas in which eradication would be so difficult as to make it impractical, but there would be little danger of commercial spread from that section. In all other parts of the South the eradication of the Argentine ant would be a simple problem as compared to the eradication of the Mediterranean fruit fly in Florida or the eradication of wild cotton from the southern part of that state.

With the damage from this pest certain to be multiplied from year to year as present infestations expand and new ones are established, and with a practical solution of the problem merely awaiting application, it seems to me that we, who are charged with the responsibility of safeguarding our states from insect ravages both now and in the future, cannot afford to overlook the challenge presented by the Argentine ant. If the eradication of this pest is a problem for federal consideration, which seems logical in view of its distribution in the South, let us unite our efforts in securing an adequate appropriation for this purpose. If it is not a subject for federal action, may we not in our respective states take steps at once to inaugurate programs for eradication?—2-22-36.

EXPERIMENTS TO CONTROL TOBACCO BUDWORM

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The tobacco budworm, *Heliothis virescens* Fab., is controlled very effectively and economically in the Florida and Georgia cigar-wrapper-producing districts by applying to the tobacco buds a mixture of lead arsenate and corn meal in a ratio of 1:75 by weight, as described by Morgan & Chamberlin (*2*). The corn meal serves not only as the poison carrier but as a bait. Experiments by Chamberlin & Garrison (*1*) have shown that the corn meal is far more attractive to the budworm than

are the tobacco bud leaves. The mixture of lead arsenate and corn meal is a quick-acting poison, and the application of only a very small quantity per plant will control the tobacco budworm. If applied properly, the mixture causes very slight injury to the foliage.

Need for further experimentation.—Although the corn meal–lead arsenate mixture is very effective for the purpose stated, the cost of the material for 16 applications per season, plus the labor involved, totals approximately $12 per acre. Therefore, and in view of the existence of cheaper bait materials of the same general physical character as corn meal, it was deemed desirable to determine the possible utility of such materials for use in budworm control. Also contributing to the need for

Fig. 1.—Applying budworm poison with the fingers, Quincy, Fla.

further experimentation was the desirability of testing the performance of other commonly used insecticides in the poison mixture, particularly those insecticides which tobacco growers might ordinarily have on hand for use in combating insects.

Experimental methods.—In all of the experiments described in this paper the budworm poisons were applied to the buds with the fingers, fig. 1. This method of application is followed universally by the shade-tobacco growers with the exception of the first two applications, which are sometimes made by means of shaker cups. These are the only known methods of applying budworm poison which give satisfactory results. Attempts to apply budworm poison with dust guns of various types have been entirely unsatisfactory in this region. Preliminary experiments with various arsenical mixtures, with nicotine dust, and with derris, applied to the tobacco buds by means of hand dusters, did not yield promising results. A dust mixture consisting of corn-meal flour and lead arsenate applied directly to the buds of low-growing tobacco with a powerful hand duster failed to give effective control.

Table 1.—Comparative results of experiments with various stomach poisons for control of tobacco budworms in shade-grown tobacco.

Poison	Ratio, Poison to Corn Meal	No. Tests	Leaves Injured by Budworm		Leaves Injured by Insecticide		Total No. Leaves Examined
			No.	Per Cent	No.	Per Cent	
Lead Arsenate	1:75	8	52	1.4	26	.7	3690
Ortho-arsenate of zinc	1:75	1	3	.6	100	20.	500
Ortho-arsenate of zinc	1:100	1	5	1.	75	15.	500
Calcium arsenate	1:75	2	11	1.1	228	22.4	1020
Calcium arsenate	1:100	6	55	2.6	254	12.1	2100
Calcium arsenate	1:125	5	49	3.5	130	9.3	1400
Calcium arsenate	1:150	4	66	5.4	89	7.3	1220
Manganese arsenate	1:75	3	73	7.8	15	1.6	940
Manganese arsenate	1:100	2	74	10.6	9	1.3	700
Magnesium arsenate	1:75	2	65	10.5	11	1.7	620
Magnesium arsenate	1:100	2	55	8.9	7	1.1	620
Magnesium arsenate	1:125	1	45	14.0	6	1.8	320
Magnesium arsenate	1:150	1	44	13.8	5	1.6	320
Sodium fluosilicate	1:75	2	48	11.4	11	2.7	420
Sodium fluosilicate	1:100	2	43	10.3	6	1.4	420
Sodium fluosilicate	1:125	2	61	14.6	5	1.2	420
Pyrethrum	1:10	1	75	15.	0	0.	500
Calcium fluosilicate	1:75	1	46	19.2	2	.8	240
Sodium sulfur compound	1:50	1	135	27.	5	1.	500
Sodium sulfur compound	1:100	1	50	10.	10	2.	500
Derris	1:75	3	378	31.5	0	0.	1200
Derris	1:37	3	406	33.8	0	0.	1200
Derris	1:25	3	443	36.9	0	0.	1200
Derris	1:18	3	474	39.5	0	0.	1200
Check, untreated		6	1512	67.8	0	0.	2230

Results with various poisons.—Table 1 shows the percentage of budworm-injured and poison-injured leaves in the control experiments with mixtures of various poisons with corn meal on cigar-wrapper tobacco. Based upon the results reported in this table, it is evident that none of the poisons tested gave satisfaction as substitutes for lead arsenate in the corn-meal bait, since all of them caused excessive foliage injury or failed to control the budworm. Since the experiments, which were performed over a period of several seasons, did not include in each series all the poisons listed, the results obtained do not give strictly comparable values

Table 2.—Comparative results of experiments with various poison carriers for control of budworms in shade-grown tobacco.

Carrier	Ratio, Lead Arsenate to Carrier	No. Tests	Leaves Injured by Budworm		Leaves Injured by Insecticide		Total No. Leaves Examined
			No.	Per Cent	No.	Per Cent	
Corn meal	1:75	8	94	2.1	31	0.7	4490
Cottonseed meal siftings	1:75	1	11	2.7	50	12.5	400
Cottonseed meal	1:75	1	12	3.4	75	21.4	350
Corn-ear meal; grain, cob and shuck	1:75	3	243	8.1	24	.8	3000
Corn-bran siftings	1:75	3	294	9.8	33	1.1	3000
Wheat-flour siftings	1:75	1	70	17.5	15	3.7	400
Sand	1:50	2	150	17.9	0	.0	840
Wood ashes	1:50	2	181	21.5	5	.6	840
Hydrated lime	1:50	2	175	20.8	30	3.6	840
Wheat-bran siftings	1:75	1	95	23.7	4	1.	400
Tobacco dust	1:75	1	103	32.2	6	1.9	320
Check, untreated		5	1236	52.8	0	0.	2340

except for comparing each of the various mixtures with the lead arsenate–corn meal mixture, which was included in each series of experiments. The relatively high degree of foliage injury which resulted from the application of mixtures of calcium arsenate and corn meal is of especial interest and demonstrates that this arsenical should not be utilized as a substitute for lead arsenate in the poisoned bait.

Results with various poison carriers.—Table 2 shows the percentage of budworm-injured and poison-injured leaves in the control experiments in which lead arsenate mixed with various carriers was used on cigar-wrapper tobacco. These results do not give strictly comparable values except for comparing the various mixtures with the lead arsenate–corn meal mixture. Judging from the data presented in this table it is evident that none of the carriers included in these tests possessed both the relatively high degree of efficiency and the safety of corn meal. Even the corn-ear meal, which consisted of the grain, cob and shuck of the ear, ground to the approximate fineness of corn meal, did not yield sufficiently promising results to warrant its use as a poison carrier on cigar-wrapper tobacco. The excessive degree of foliage injury resulting from applications of cottonseed-meal mixtures appeared to be due to the glutinous nature of the material, which caused it to adhere to the tender bud leaves, thereby preventing their normal expansion.

Conclusion.—The experiments, as described in the foregoing paragraphs, failed to reveal any satisfactory and safe substitute for the lead arsenate–corn meal mixture and demonstrated that several of the mixtures tried were harmful and should not be used by tobacco growers.—9-8-36.

Literature Cited

(*1*) **Chamberlin, F. S.** and G. L. Garrison, 1926. Corn meal as an attrahent to the tobacco budworm, *Heliothis virescens* Fab. Jour. Econ. Ent. 19(1):191. Feb.

(*2*) **Morgan, A. C.** and F. S. Chamberlin, 1927. The tobacco budworm and its control in the Georgia and Florida tobacco-growing region. U.S.D.A. Farmers' Bul. 1531. 9 pp., illus.

EFFECTIVENESS OF LOW CONCENTRATIONS OF NICOTINE

IN COMBINATION WITH OTHER MATERIALS AGAINST BLACK PECAN APHID

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During 1932, 1933 and 1934, experiments were conducted near Albany, Ga., in the control of the black pecan aphid, *Melanocallis caryaefoliae* Davis, with low concentrations of nicotine in combination with various other materials. In spraying large pecan trees for the control of this aphid, which infests the foliage throughout the tree, a considerable quantity of spray liquid is needed. Trees 15 to 20 years of age re-

Table 1.—Analyses* of white-oil emulsions used in experiments in control of the black pecan aphid, Albany, Ga., 1932 to 1934.

Oil No.	Percentage Actual Oil	Seconds Viscosity, Saybolt, at 100° F.	Percentage Unsulfonated Residue	Percentage Volatility, 4 Hours at 110° C
1	82.2	65	97	6
2	63.8	90	86	8.6
3	82.7	55	74	41.9
4	82.7	65	86	19.7
5	80.1	63	92	

* By the Division of Insecticide Investigations.

quire 30 to 40 gallons for proper coverage, and older trees require even more. Spraying pecan trees with nicotine at the usual dilutions is rather expensive, and a reduction in its concentration is therefore desirable.

Nature of injury.—The black pecan aphid is one of the most destructive defoliators of pecan trees. Its feeding results in a bright yellow spot on the foliage, apparently caused by the injection of a toxic substance which destroys the chlorophyll. The yellow area eventually turns brown

Table 2.—Mortality of black pecan aphid when sprayed with low concentrations of nicotine sulfate in combination with various spray conditioners.

Test No.	Concentration of Nicotine Sulfate	Spray Conditioner	Concentration of Spray Conditioner	Date of Application	Temperature, °F	No Aphids Counted	Percentage Aphids Killed
1	1:1000	Bordeaux mixture	3:4:50	8-11-32	84	1796	100.
2	1:2000	Bordeaux mixture	3:4:50	8-11-32	84	2325	99.6
3	1:3000	Bordeaux mixture	3:4:50	8-15-32	82	2730	99.4
4	1:4000	Bordeaux mixture	3:4:50	8-15-32	82	2070	99.7
5	1:5000	Bordeaux mixture	3:4:50	8-15-32	82	1872	95.9
6	1:4000	Bordeaux mixture	2:2.5:50	9-25-34	72	2431	95.4
7	1:4000	Oil emulsion No. 1	1.5%	9- 8-32	85	3076	99.
8	1:4000	Oil emulsion No. 1	1%	9- 8-32	85	2675	97.2
9	1:4000	Oil emulsion No. 2	1%	8-16-33	88	4963	99.1
10	1:4000	Oil emulsion No. 3	1%	8-16-33	88	4891	98.9
11	1:4000	Oil emulsion No. 4	1%	8-17-33	84	6192	99.6
12	1:4000	Oil emulsion No. 5	1%	9-20-34	72	2769	97.1
13	1:4000	Oil emulsion No. 1	.5%	9- 8-32	85	2240	96.6
14	1:4000	Oil emulsion No. 2	.5%	8-16-33	88	5164	99.4
15	1:4000	Oil emulsion No. 3	.5%	8-16-33	88	5684	98.5
16	1:4000	Oil emulsion No. 4	.5%	8-17-33	84	4783	99.2
17	1:4000	Oil emulsion No. 5	.5%	9-25-34	72	3773	95.2
18	1:4000	Potassium oleate soap	6*	9-12-32	78	1925	99.6
19	1:4000	Potassium oleate soap	6*	8-18-33	82	5021	99.2
20	1:4000	Potassium oleate soap	4*	9-12-32	78	2180	96.3
21	1:4000	Potassium oleate soap	4*	8-18-33	82	4901	97.9
22	1:4000	Potassium oleate soap	4*	9-20-34	81	2960	91.9
23	1:4000	Potassium oleate soap	2*	9-20-34	79	2720	85.6
24	1:4000	Potassium fish-oil soap	6*	9-14-32	74	2485	88.5
25	1:4000	Potassium fish-oil soap	6*	8-18-33	82	5962	89.9
26	1:4000	Potassium fish-oil soap	4*	9-14-32	74	1634	79.3
27	1:4000	Potassium fish-oil soap	4*	8-17-33	84	4871	87.4
28	1:4000	Potassium fish-oil soap	4*	9-24-34	76	2407	91.4
29	1:4000	Potassium fish-oil soap	2*	9-24-34	76	2313	73.1
30	1:4000	Fish oil	2†	9-20-34	81	2260	84.5
31	1:4000	Fish oil	1†	9-20-34	81	1751	26.9
32	1:4000	Rosin fish-oil soap	4*	9-24-34	80	1855	71.1
33	1:4000	Rosin fish-oil soap	2*	9-24-34	80	2124	33.5
34	1:4000	Calcium caseinate	1*	9-24-34	76	2678	44.2
35	1:4000	Calcium caseinate	.5*	9-24-34	76	1653	23.8
36	1:4000	Lignin pitch, powder	1*	9-20-34	79	2980	20.8
37	1:4000	Lignin pitch, liquid	.25%	9-20-34	79	3152	31.
38	1:4000	Pine tar oil	1%	9-25-34	72	2215	45.2
39		Check, unsprayed		9- 8-32	85	2936	1.2
40		Check, unsprayed		8-18-33	82	4895	1.2
41		Check, unsprayed		9-25-34	78	1791	7.

* Pounds per 100 gallons. † Pints per 100 gallons.

and acquires a parched appearance. When a number of aphids are present on a leaf, these spots merge and the leaf drops prematurely. Such premature defoliation has a direct effect on the current pecan crop by cutting off the supply of plant food and thus preventing the proper filling of the nuts. Furthermore, since the extent to which pecan trees will produce pistillate bloom in the spring depends largely on their ability to store up food reserves in the fall of the year, defoliation also has an adverse effect on the crop of the following year.

Materials.—The materials used with nicotine in these tests included Bordeaux mixture, five white-oil emulsions, three proprietary soaps, fish oil, calcium caseinate, powdered lignin pitch, liquid lignin pitch, and a pine-tar oil. The source of nicotine was a standard brand of nicotine sulfate solution containing 40 per cent of nicotine. Analyses of the white-oil emulsions are given in table 1. The concentrations of the materials and the results of the tests are summarized in table 2. The soaps used contained approximately 40 per cent soap.

Conclusions.—Nicotine will control the black pecan aphid at strengths as low as 1:4000 when combined with Bordeaux mixture, white-oil emulsions, and potassium oleate soap at the higher strengths used. In tests 13 to 17, inclusive, nicotine sulfate and white-oil emulsions gave 95.2 to 99.4 per cent mortality when the emulsion was used at a strength of .5 per cent of the stock mixture. Variation in the actual oil content, viscosity and unsulfonated residue of the five emulsions, tests 8 to 17, inclusive, influenced but slightly the effectiveness of the sprays. For example, in test 13 white-oil emulsion No. 1, containing 82.2 per cent actual oil and 97 per cent unsulfonated residue, and having a viscosity of 65 seconds Saybolt, gave a kill of 96.6 per cent, while in test 14 white-oil emulsion No. 2, containing 63.8 per cent actual oil and 86 per cent unsulfonated residue and having a viscosity of 90 seconds Saybolt, gave a kill of 99.4 per cent. Potassium oleate soap also increased the effectiveness of the nicotine sulfate when used at strengths of 4 to 6 pounds per 100 gallons, tests 18 to 22 inclusive, but to an appreciably less extent when used at 2 pounds to 100 gallons, test 23. With potassium fish-oil soap the percentages of kill were lower. Low mortality was obtained in the tests with fish oil, rosin potash fish-oil soap, liquid lignin pitch, powdered lignin pitch, calcium caseinate, and pine-tar oil.

The most significant phase of the results was the high mortality resulting from the use of nicotine sulfate 1:4000, combined with Bordeaux mixture, which is used for the control of the pecan diseases during the growing season.

At the present market prices the use of nicotine sulfate 1:4000 with either Bordeaux mixture or one-half per cent concentration of white-oil emulsion results in a saving of 50 per cent, and the same dosage of nicotine sulfate with potassium oleate soap at 6 pounds per 100 gallons gives a saving of 37 per cent, as compared with the cost of the same materials when nicotine sulfate is used at the rate of 1:1000.—9-3-36.

FEDERAL quarantine regulations relating to the pink bollworm of cotton were revised effective August 17 to add the Texas counties of Cameron, Hidalgo, Starr and Willacy to the lightly infested area.

RELATION OF FERTILIZERS TO SEED CORN MAGGOT INJURY TO SPINACH SEEDLINGS

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Seed corn maggot, *Hylemyia cilicrura* Rond., is known to attack spinach during both its seedling and more mature stages of growth. In unpublished notes W. A. Thomas described injury to spinach seedlings by this insect at Chadbourn, N. C., in December 1923. Mr. Thomas also found the insect feeding in February 1924 at Chadbourn on the stalks and on lower leaves of older spinach partially covered by soil. On December 10, 1918, A. P. Swallow,[2] special field agent of the Bureau of Entomology, submitted to F. H. Chittenden specimens of an insect found feeding in the hearts of spinach on irrigated land near Laredo, Tex. The specimens were identified by Dr. Chittenden as the seed corn maggot. In 1933 C. E. Smith (*1*) published an account of similar injury during December 1931 to spinach in the Winter Garden district of Texas. During the course of studies of the seed corn maggot as a potato pest and of wireworms as pests of spinach, the writer observed an infestation of spinach seedlings by the seed corn maggot near Charleston, S. C., in November 1926. Specimens reared from larvae attacking the spinach were determined by J. M. Aldrich[3] as *Hylemyia cilicrura*.

South Carolina spinach crop.—Spinach is grown commercially in South Carolina during the fall and winter months, the largest acreage being in the vicinity of Charleston. According to the estimates of the Bureau of Agricultural Economics (*2*) the average yearly spinach acreage during four seasons (1926–27 to 1929–30) in South Carolina was 635 acres, with an average annual yield of 143,000 bushels, and a farm-price value of approximately $125,500. Based on the results of field tests in the Charleston area during this period it is estimated that under conditions of prevailing fertilizer practices the seed corn maggot was responsible for a decrease of approximately 23 per cent in the yield of spinach.

Period of seed corn maggot injury to spinach seedlings.—To make the crop profitable, Charleston growers have found that spinach should be planted as soon as possible in the fall. The seeds do not germinate well, however, unless the soil is cool and moist. Owing to these factors, spinach is necessarily planted from about October 1 to November 15, which results in the crop being in the seedling stage at the time when the large fall and early winter larval population of the seed corn maggot is present. The larvae are most abundant in the Carolinas from late October through March. A late planting, seeded early in December, was observed

[1] Acknowledgments are due W. A. Thomas for his general supervision of the project; and to J. M. Harrison, James W. Geraty, and E. W. King of Charleston, S. C., who greatly facilitated the investigations by placing at our disposal without compensation their land, farm buildings, supplies and equipment.

[2] Unpublished correspondence.

[3] Letter of W. H. White to the writer, dated Feb. 16, 1927.

to have a 15 to 25 per cent infestation on January 9, 1930. The crop had been planted on land containing large quantities of the remains of a fall bean crop. Thus in the Charleston area the spinach crop is susceptible to seed corn maggot injury throughout the entire growing season, but the commercial plantings are damaged most during the period of the sprouting and seedling stages that occur during November.

Nature of injury.—Seed corn maggots feed by rasping the tissues of the plants. Any underground portion of a spinach seedling may be attacked, but injury to the hypocotyl is most noticeable. The feeding may result in the destruction of the germinating seed, the young sprout, or the hypocotyl. The maggots often tunnel out of sight into the underground portion of the hypocotyl, their presence being detected only by the injury at the point of entrance, by the swollen condition of that part of the plant where large larvae are located, or by the wilting of affected plants.

As many as six maggots have been noted feeding on one spinach seedling. One insect was observed to have damaged as many as three plants. Young plants are apparently preferred to older ones and younger plants suffer more from the feeding. Injured areas first become soft and watery in appearance, later turning darker. Only a small amount of injury is necessary to kill a spinach seedling. The most noticeable evidences of an infestation are wilting and dying of the seedlings, poor stands of plants and decreased yields. Since dead plants quickly become dried, break off at the soil surface, and are blown away, seed corn maggot infestations of spinach sometimes pass unnoticed by the grower. Light infestations may result in a needed thinning of the plants. However, such infestations are usually undesirable in that they do not thin the plants uniformly and do increase the seed requirements.

Possible relation of plant fertilizers to infestations.—In other studies[4] of the habits of the seed corn maggot the writer found that adults of the species are attracted to such organic substances as cottonseed meal, fish meal, fish scrap, animal tankage and dried blood. Also, the insect had been found to deposit eggs freely in soil containing these materials and to be able to use the substances as larval food. The fertilizer mixtures used on spinach in the Charleston section often contain varying quantities of the organic sources of plant food mentioned above. When intended for spinach, which obtains the necessary plant food near the soil surface, the fertilizers are placed near or on the top of the ground, at which place they would be most likely to affect the insect's activity.

It was noted in trapping studies[4] that partly organic fertilizer mixtures containing superphosphate prepared with "sludge" sulfuric acid were not so attractive to adults of the seed corn maggot as those prepared with unused acid. Sludge is the local name given in the Charleston area to sulfuric acid that has been used in the refining of petroleum products. Superphosphate prepared with this acid has a characteristic odor which evidently offsets to some extent the attractiveness of the organic materials to the seed corn maggot. The trapping studies also indicated that castor-bean meal, a product sometimes used in fertilizer mixtures, is not

[4] Unpublished data.

as attractive to adults of the seed corn maggot as the previously mentioned organic substances. Consequently, it was thought that fertilizers might play an important rôle in seed corn maggot infestations.

Field studies.—It was realized at the outset that prevention of seed corn maggot injury to spinach through the use of insecticides would be most difficult and probably impractical because of several factors. To learn something of the possible relation of fertilizers to the problem, field studies were begun in the fall of 1927 and continued each season through that of 1930–31. All work was done on fine sandy loam soils of the Norfolk series on privately owned farms in the vicinity of Charleston, S. C.

The general plan of the studies was to use a series of fertilizer mixtures in tests located on several farms each season and obtain comparative records of either oviposition around the plants, maggot infestation, plant stand, crop yield, or all of these factors. It was found to be rather difficult to obtain accurate data on the degree of maggot infestation because of the frail nature of the plants, the underground location of the injured portions, and the existence of similar injury caused by other insects and by disease. However, it is believed that these accompanying factors were more or less constant in individual tests and that their effects upon the experiments were largely taken care of by replication of the different treatments. Records of plant stand and yield were considered the most dependable measure of the comparative differences in the degree of seed corn maggot damage.

A total of 14 field experiments were conducted during the four seasons of study on the problem. The number of these tests varied from two in the 1930–31 season to six in that of 1927–28. Replications of each treatment in the individual tests ranged from one during the first season to four during the final season. The plots for each fertilizer treatment consisted of bedded strips of land $5\frac{1}{2}$ feet wide and ranging in length in the different experiments from 135 to 450 feet. Thus the plots were approximately one fifty-eighth to one-eighteenth of an acre. There were four rows of spinach on each plot. In tests where the treatments were replicated the areas devoted to each treatment were located according to a restricted randomized block arrangement.

The experiments consisted of field tests in which both commercial and special fertilizer mixtures containing different proportions of organic materials were applied shortly before the crop was planted, and of tests in which no fertilizer was applied until the plants were large enough to be thinned to the desired stand. Plants that have attained this stage of growth are usually not susceptible to the type of seed corn maggot injury with which these studies were concerned. Cottonseed meal, fish scrap or meal, animal tankage and castor-bean meal were the organic constituents of the fertilizers. These are the most commonly used organic components of spinach fertilizers used in the Charleston area. As castor-bean meal had not proved so attractive to the insect as the other materials, it constituted the only organic ingredient of one of the mixtures tested. Mixtures containing cottonseed meal, fish products or animal tankage always contained at least two of these ingredients.

The proportion of organic and inorganic materials in the fertilizer mixtures was based on the ratio of available nitrogen furnished by the two classes of ingredients. Formulae of the mixtures used in the tests were so calculated as to have either all, one-half, or none of the nitrogen furnished by inorganic materials. The composition of the fertilizers was such that, as a whole, these three types of mixtures were approximately 0, 25 and 50 per cent organic, respectively. Listed in accordance with fertilizer trade practices prevailing in South Carolina at the time of the studies, most of the fertilizer mixtures used in the tests were of a 7:6:5 analysis, in order of the available phosphoric acid, ammonia and potash content, respectively. During the first three seasons the fertilizers were

Table 1.—Summary of data from experiments to determine relation of fertilizers to seed corn maggot infestations of spinach seedlings, Charleston, S. C., 1927–31.

Fertilizer Applied Before Planting Crop	No. Replications of Treatment	No. Egg-infested Plants	Total No. Eggs	No. Maggot-injured Plants	Per Cent Plant Stand	Average Yield in Pounds per Acre
A.—Fertilizer Composition Tests						
None	18	1	2	2	71.	4544
All-mineral mixture	18	1	1	4	78.6	3794
25% organic mixture, containing sludge superphosphate	18	9	14	13	66.1	3611
Commercial mixtures	18			22	62.	3497
25% organic mixture, containing ordinary superphosphate	18	12	43	17	53.9	2877
25% organic mixture, castor-bean meal as only organic material	18	15	33	2	55.9	2676
50% organic mixture, all nitrogen from organic materials	18	52	506	36	48.3	2316
Castor-bean meal alone	6	23	64		48.9	
B.—Fertilizer–Soil-mixing Tests						
No fertilizer	4			2	64.8	
Commercial brands, not well mixed into soil	4			19	56.6	
Commercial brands, well mixed into soil	4			15	53.5	

applied at the rate of 1000 pounds per acre, but the last season the rate was reduced to 750 pounds, since there had been indications that the heavier application interfered with the germination and early growth of the spinach. The fertilizers were applied by hand in a manner and under conditions which confined the materials to the intended area.

In the case of those tests having to do with fertilizer composition, the fertilizers were broadcast over the soil surface and then mixed into the upper 3 inches with one or two trips of a Meeker harrow, the number of trips required depending upon soil conditions. The use of a Meeker harrow is probably the most common method of mixing spinach fertilizers into the soil in the Charleston section.

In those tests in which it was desired that the fertilizer be more thoroughly incorporated into the soil, the fertilizer was broadcast and then mixed into the upper 6 inches of soil with both disk and Meeker harrows.

The studies also included comparisons of fertilizer mixtures containing sludge superphosphate with those containing ordinarily prepared superphosphate. These mixtures were 25 per cent organic, containing cottonseed meal, fish products and animal tankage.

Those plots which received no fertilizer application prior to planting of the crop were fertilized after the plants had been thinned. This fertilization consisted of the application by hand between the plant rows of an all-mineral mixture of the same analysis and at the same rate as other mixtures used in that particular series of tests.

Results.—A summary of the data obtained from all the experiments of the four seasons is given in table 1. Differences in the number of tests

Fig. 1.—Relation of fertilizers to seed corn maggot infestations of spinach. Plot 6A, all-mineral mixture; Plots 7A and 4C, a 50 per cent organic mixture; Plot 5C, no fertilizer before crop was planted.

made of each treatment and in the type of records made during various seasons are due to the fact that as the work on the project progressed some treatments were discontinued and others were added, and the methods of evaluating the treatments were changed. Since the results of efforts to obtain accurate and adequate information on actual seed corn maggot infestations of the variously treated field plots proved rather unsatisfactory under existing conditions, the infestation data presented are only indicative of the relative effect of the different fertilizers upon the population of the insect.

Oviposition records represent the total number of eggs found at the base of either 50 or 100 plants of each of five replications during two seasons.

Larval infestation data of part A of the table represent the total number of seed corn maggot-injured plants found at one date on 50 linear feet of each plot of four treatment replications, combined with the number of such injured plants out of 15 dying plants in one treatment replication. Such data of part B represent the total number of infested plants on the entire area of four replications at three different dates during one season.

Plant stand records listed in part A were made on the entire plot areas of a total of 17 treatment replications during four seasons, the data presented being a weighted average of these figures; the data of part B represent the stand of plants on the entire treatment areas of four replications during one season.

Yield data given represent the weighted average of the yield of the entire plot areas of a total of 12 replications conducted during three seasons.

Of the 18 commercial fertilizer mixtures tested, 13 contained sludge superphosphate and the others contained the commonly used superphosphate. Six of the commercial mixtures were of a 7:8:5 analysis and four of a 7:5:7 analysis, in order of their phosphoric acid, ammonia and potash content, respectively.

Blank spaces in the table indicate that no data were obtained.

Figure 1, consisting of photographs of representative plots of experiment 1 of the 1930–31 season, illustrates typical examples of the differences in plant stand resulting from the use, in advance of the planting of spinach, of either no fertilizer, an all-mineral fertilizer, or a partly organic fertilizer mixture.

Discussion.—It is quite evident that the least seed corn maggot infestations, the best stands of plants and the highest yields were obtained on those areas on which either no fertilizer or an all-mineral mixture was used prior to planting of the crop. The infestation was greatest and the plant stands and the yields were least on those areas receiving fertilizer mixtures containing such organic sources of plant food as cottonseed meal, fish meal and animal tankage. The degree of insect damage was generally in proportion to the amount of the organic materials used. The use of castor-bean meal instead of the three materials just named did not materially lessen the infestation.

Field plots which received no fertilizer until after the plants were thinned produced 96.2 per cent more marketable spinach than those fertilized with a 50 per cent organic mixture before being planted, and 57.9 per cent more spinach than plots fertilized with a 25 per cent organic mixture containing ordinary superphosphate. The yield of plots receiving an all-mineral fertilizer mixture before being planted was 63.8 per cent more than that of plots receiving a 50 per cent organic mixture, and 31.8 per cent more than that of those receiving a 25 per cent organic mixture.

Plots that were fertilized in advance of planting with partly organic

mixtures containing sludge superphosphate had smaller maggot infestations, better plant stands and gave higher yields than those containing the commonly prepared superphosphate. The sludge superphosphate evidently offset to some extent the attrahent properties of the organic substances.

The commercial fertilizer mixtures that were used, none of which derived more than 50 per cent of their nitrogen from organic materials, and approximately one-half of which mixtures contained sludge superphosphate, resulted in yields greater than those of the all-organic ammoniates and the specially prepared mixtures containing the common superphosphate. Plots fertilized with these commercial brands produced less spinach than those receiving either no fertilizer or an all-mineral mixture in advance of planting.

In the limited number of tests conducted, the thoroughness with which the fertilizers were mixed into the top layer of soil did not materially affect the seed corn maggot infestation or the plant stand. The fertilizers could not be placed very deeply into the soil because the plant roots are near the surface.

The most severe infestations occurred in those experiments which were located on soils containing the greatest quantity of partly decayed vegetation, especially that of such crops as beans.

Summary.—Spinach is often attacked in both seedling and more mature stages of its growth by larvae of *Hylemyia cilicrura* Rond., the seed corn maggot. The seedling stage of the crop is particularly susceptible to attack by the insect in the coastal area of the Carolinas during the late fall and early winter months. Commercial fertilizers are used extensively for spinach production in that region and these fertilizers often contain organic materials known to attract and stimulate oviposition of the insect and to serve as food for its larvae.

A total of 14 field experiments were conducted in the vicinity of Charleston, S. C., during four seasons (1927 to 1931) to learn something of the possible relation of these fertilizers to seed corn maggot infestations of spinach seedlings.

Fertilizers, when applied before the crop was planted, were found to play an important rôle in the severity of seed corn maggot attacks on spinach seedlings. The presence in fertilizer mixtures of such organic materials as cottonseed meal, fish products and animal tankage greatly increased the insect infestation, thereby resulting in decreased plant stands and crop yields. The decreases were, in general, in proportion to the quantity of the organic materials used. Insect infestations were least and plant stands and yields were highest when no fertilizer was used in advance of the planting, the desired quantity of fertilizer being put on after the crop was thinned and had passed the susceptible seedling stage.

The use in a 50 per cent organic mixture of a superphosphate made with sludge sulfuric acid resulted in an increase in yield as compared to the use of a similar fertilizer mixture containing ordinary superphosphate.

Although in trapping studies castor-bean meal had not proved so attractive to adults of the seed corn maggot as had other organic materials,

the use of castor-bean meal in a 50 per cent organic fertilizer mixture resulted in only a slight increase in yield over that of a similar mixture containing cottonseed meal, fish meal and animal tankage.

Mixing the fertilizer materials more thoroughly into the soil apparently does not offer worthwhile possibilities for reducing seed corn maggot injury to a spinach crop.

With fertilizer treatment and other factors similar or equal, the most severe infestations occurred in the soils containing the greatest quantity of decaying vegetation, particularly that of such crops as beans.—8-29-36.

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REPELLENCY OF PINE-TAR OIL TO WOUND-INFESTING BLOWFLIES

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As a result of the serious outbreak of the screw worm, *Cochliomyia americana* C. and P., in the southeastern states in 1933 and the following two years, investigations were begun at Valdosta, Ga., in the summer of 1935 to determine the most effective means of control.

In 1926 and 1928, Laake, Parman, Bishopp, & Roark (*1*, *2*) reported on investigations undertaken to find substances that could be used to prevent oviposition by wound-infesting flies. After an extensive series of tests with many materials, they found pine-tar oil to be the most practical repellent, because of its effectiveness, cheapness, ready availability, nontoxicity to animals and excellent adhesiveness. This material was therefore used in the investigations conducted in 1935.

Materials and procedure.—During the months of August, September, October and November, pine-tar oil (specific gravity 1.065) was applied at intervals of one to five days to hip wounds on goats and sheep that had previously been infested with *C. americana*. The wounds were about 1½ inches wide by 2½ inches long and 1½ inches deep. The condition of the wounds when the pine-tar oil was first applied varied markedly. Some were badly swollen, but many showed little or no swelling. The black discharge and odor characteristic of screw worm-infested wounds were usually present, but some of the wounds were filled with viscous pus and had an obnoxious odor. The quantity of dead tissue also varied greatly. After the wool or hair had been clipped from around the wound, the material was applied with a 1-inch paint brush to the open surface of the wound and a strip about 1 or 2 inches wide around it. This usually required one or two brushfuls (3 to 6 cc.).

Six groups of these animals were exposed continuously under natural conditions. One group was treated with pine-tar oil every day, another every other day, another every third day, and so on, except the sixth

group, which was composed of untreated check animals. Whenever possible, two or three animals were kept in each group. This was accomplished by replacing those animals that died or healed by other wounded animals. Sometimes, however, a suitable animal was not on hand.

Results.—The results of these tests are summarized in table 1. As the screw worm research at Valdosta was directed primarily toward control of *C. americana*, the infestation records were divided into egg masses of *C. americana* and egg masses or batches of larvae of other wound-infesting flies, which were chiefly *C. macellaria* Fab., *Phormia* spp., *Lucilia* spp., and *Sarcophaga* spp. In table 1, however, an infestation refers to all the eggs or larvae deposited on a wound in the 24-hour period between observations. The number in a single infestation may vary

Table 1.—Repellent action on wound-infesting flies of pine-tar oil (specific gravity 1.065) applied to wounds on goats and sheep at intervals of one to five days.

Days Between Treatments	Total No. Animals		Average No. Days Each Animal Exposed	Total No. Infestations	Average No. Infestations per Animal per Day
	Goats	Sheep			
1	9	1	33.4	3	.01
2	9	1	28.1	21	.07
3	8	1	19.2	23	.13
4	7	1	33.4	47	.18
5	9	0	24.4	40	.18
Untreated	9	2	26.5	80	.27

therefore from a few to several thousand. From the standpoint of c trol, any reinfestation of a wound, whether by a few or many larvae, would probably require treatment to prevent further reinfestations. The determinations of the number of egg masses deposited by *C. americana* were reasonably accurate, but only an estimate of the number of egg masses or batches of larvae deposited by secondary wound-infesting flies was made.

One Day Between Treatments.—On the animals that were treated daily with pine-tar oil, three egg masses of *C. americana* and none of other species were deposited during a total of 334 animal-days (number of days all animals were exposed). Three animals received one egg mass each. Two of these masses were deposited between the first and second applications of pine-tar oil and the third was laid after the second application. No eggs were deposited after three or more daily applications had been made.

Two Days Between Treatments.—On the wounds treated at two-day intervals, 22 *C. americana* egg masses and approximately 28 egg masses or batches of larvae of other flies were deposited during the 281 animal-days of exposure. Not an egg mass of *C. americana* and only one egg mass of secondary species was laid during the first day after the application. Of the total number of infestations; 13 were *C. americana* alone, three were mixed *C. americana* and other species, and four contained no *C. americana* eggs. No infestations occurred after nine applications of pine-tar oil, and only two after six applications.

THREE DAYS BETWEEN TREATMENTS.—On the animals that were treated at three-day intervals, 15 *C. americana* egg masses and about 38 egg masses of secondary screw worm flies were observed over a period of 173 animal-days. During the first day after the application only one egg mass of *C. americana* was deposited and none of secondary flies; on the second day there were six masses of *C. americana* eggs and five egg masses of secondary flies. On the third day after treatment there were six egg masses of *C. americana* and approximately 32 egg masses of other flies. One of these wounds received one *C. americana* egg mass and about 25 egg masses of secondary species on the same day; the animal died the following day. The sheep in this test received two *C. americana* and one egg mass of a secondary species, all laid on the same day. No new infestations occurred after nine applications of pine-tar oil and only two new infestations after five applications.

FOUR DAYS BETWEEN TREATMENTS.—On the animals treated at four-day intervals, 36 egg masses of *C. americana* and about 29 egg masses or batches of larvae of other flies were deposited during the 267 animal-days the wounds were exposed. Of these, three *C. americana* egg masses and one batch of sarcophagid larvae were observed during the first day after treatment, and 10 egg masses of *C. americana* and about six egg masses or batches of larvae of other flies were found during the second day. On the third day 10 egg masses of *C. americana* and seven egg masses or batches of larvae of other flies were deposited. On the fourth day the total number of egg masses was 28, of these 13 were *C. americana* and 15 were other flies. No new infestations occurred after eight applications of pine-tar oil.

FIVE DAYS BETWEEN TREATMENTS.—On the nine goats treated at five-day intervals, 94 egg masses were deposited during the 220 animal-days the wounds were exposed. Of these, 33 were *C. americana* and 61 were of other flies. One *C. americana* and one egg mass of a secondary species of screw worm fly were deposited on the first day after treatment. There were 10, 10, 9 and 3 *C. americana* egg masses and about 14, 15, 22 and 9 egg masses or batches of larvae of other wound-infesting flies on the second, third, fourth and fifth days, respectively. No reinfestation took place after five applications of pine-tar oil.

Of the 109 egg masses of *C. americana* that were deposited on the treated animals, regardless of the interval between treatments, only seven were laid the day after treatment.

UNTREATED ANIMALS.—On the untreated check animals, a total of 132 egg masses of *C. americana* and 473 egg masses or batches of larvae of other wound-infesting flies were deposited during the 291 animal-days the wounds were exposed. The wounds were the most attractive to flies during the first and second weeks of exposure, but in many instances they were slightly attractive for twice that length of time, and one animal continued to become reinfested for 38 days. However, two goats in this group that had rather small wounds and were active in fighting the flies did not receive a single reinfestation.

Discussion.—The number of egg masses deposited throughout the course of the experiment was fairly uniform, indicating that screw worm

flies were abundant in the field at this time. The wounds that were not treated with pine-tar oil formed a hard, dry scab, which usually had pus under it for a long time, whereas the wounds treated with pine-tar oil healed more readily and seldom, if ever, formed a scab similar to those of the untreated wounds.

The number of animals tested was too small to do more than indicate what might be expected under similar conditions, since there are many variable factors, such as the attractiveness of the different wounds to screw worm flies, the attractiveness of the same wound at different times, and the way in which the experimental animals fight the flies that are attracted to their wounds. Moreover, under different climatic and biological conditions the results might be quite different.

Summary.—Pine-tar oil was applied at intervals of one to five days to wounds on goats and sheep that had been infested with screw worms. Daily applications of this material reduced the reinfestations nearly 97 per cent. Applications at two or three-day intervals reduced the number of reinfestations but were much less effective than daily treatments. Treatment at four or five-day intervals slightly reduced the number of reinfestations.

Even where the number of reinfestations was not greatly reduced, the total number of egg masses or larvae deposited on the wounds that had been treated was markedly less than on the untreated wounds.—8-31-36.

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LABORATORY TESTS ON COMPARATIVE EFFECTIVENESS OF FUMIGANTS AGAINST CIGARETTE BEETLE IN CIGARS

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Since there is a dearth of published information relating specifically to the fumigation of cigars for the control of the cigarette beetle, *Lasioderma serricorne* Fab., the writers consider it desirable to publish some data obtained during the period August 17, 1927, to October 9, 1928, on the effectiveness of several materials for the fumigation of cigars.

Jones (*2*) in 1913 published data relating to the fumigation of cigars and unmanufactured tobacco. In an extensive series of tests he showed that hydrocyanic acid gas could be used to fumigate cigars without impairing the smoking quality. Mackie (*3*) in 1916 published the results of some experiments in the fumigation of cigars in partial vacuum. He carried out tests with carbon disulfide and concluded that the gas did not

Table 1, Part I.—Laboratory experiments at atmospheric pressure with fumigants against larvae and pupae of the cigarette beetle in cigars, Tampa. Fla., 1927 to 1928.

Experiment No.	No. Tests	Dosage	Hours Exposure	Total Larvae Used	Larval Mortality		Total Pupae Used	Pupal Mortality		Av. Max. Temp.	Av. Min. Temp.	Av. Max. Relative Humidity	Av. Min. Relative Humidity
					no.	per cent		no.	per cent	°F	°F	per cent	per cent
						Chloropicrin							
1	3	1*	24	180	134	74.4				81	71	88	64
2	2	1.5	24	120	105	87.5				79	68	87	66
3	1	1.75	24	60	60	100				89	73	84	34
4	1	2	15	55	55	100				86	74	74	50
5	5	2	24	320	318	99.5				85	73	88	53
6	1	2.5	15	50	50	100				86	74	74	50
7	1	2.5	24	46	45	97.8				92	76	88	31
8	1	3	15	60	54	90				71	68	86	80
9	1	3	24	30	28	93.5				86	76	90	46
10	1	3.5	15	60	59	98.3				87	74	85	54
11	2	4	15	120	119	99.2				80	74	90	84
12	2	4.5	15	120	117	97.5				81	74	88	71
13	1	5	8	50	41	82				72	70	90	81
14	3	5	15	185	183	98.9				84	76	89	64
						Ethylene Dichloride–Carbon Tetrachloride Mixture							
1	1	10	24	50	41	82	10	6	60.	80	72	80	40
2	2	12	24	75	44	58.7	45	24	53.3	85	77	82	58
3	1	14	24	90	65	72.2	120	32	26.7	79	57	76	49
4	1	16	24	63	57	90.5	17	16	94.1	77	62	70	32
5	3	18	24	150	124	82.7	50	46	92.	76	66	71	44
6	2	20	10	100	51	51				78	68	70	48
7	4	20	24	230	216	93.9				79	68	82	50
						Carbon Tetrachloride							
1	1	20	24	70	60	85.7				80	63	60	28
2	3	25	24	160	142	88.8	20	18	90	79	67	70	43
3	2	30	24	110	106	96.3				86	73	71	38
4	5	35	24	266	240	90.2	44	31	70.5	88	73	89	47
5	1	50	8	40	18	45				84	75	83	60
6	1	60	8	50	26	52	20	16	80	84	75	83	60

* Dosages in pounds per 1000 cubic feet.

Table 1, Part II.—Laboratory experiments at atmospheric pressure with fumigants against larvae and pupae of the cigarette beetle in cigars, Tampa, Fla., 1927 to 1928.

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Experiment No.	No. Tests	Dosage	Hours Exposure	Total Larvae Used	Larval Mortality		Total Pupae Used	Pupal Mortality		Av. Max. Temp.	Av. Min. Temp.	Av. Max. Relative Humidity	Av. Min. Relative Humidity
					no.	per cent		no.	per cent	°F	°F	per cent	per cent
						Carbon Disulfide							
1	1	3*	15	100	100	100				85	76	90	60
2	4	4	8	328	189	57.6	−106	93	87.7	83	77	73	44
3	12	4	15	620	533	85.9	130	122	93.8	82	65	75	47
4	6	4	24	284	283	99.7	101	100	99	85	76	72	45
5	1	6	8	70	69	98.6				87	77	81	45
6	6	6	15	328	320	97.5	72	71	98.6	79	71	83	73
7	5	6	24	240	240	100	72	72	100	88	75	89	53
8	5	8	8	333	333	100	37	36	97.3	87	77	79	47
9	9	8	15	419	418	99.8	116	116	100	82	72	87	64
10	5	10	8	222	222	100	69	69	100	91	79	82	41
11	4	40	4	220	175	79.5	20	20	100	82	77	67	42
12	1	50	4	50	46	92				88	75	63	32
						Hydrocyanic Acid							
1	1	7†	8	50	46	92				92	82	73	58
2	3	7	15	130	127	97.7	10	10	100	84	70	96	67
3	1	10	8	30	30	100	10	10	100	89	76	87	62
4	6	10	15	300	286	95.3	60	60	100	84	69	89	53
5	2	12	15	80	74	92.5	60	53	88.3	83	71	88	43
6	1	14	15	20	20	100	40	37	92.5	85	70	89	35
7	3	15	15	140	138	98.6	150	147	98	83	74	88	44
8	2	16	8	120	112	93.3	20	15	75	82	69	82	40
9	1	16	15	60	59	98.3	50	50	100	83	75	88	50
10	2	16	24	105	104	99	20	20	100	87	72	85	45
11	2	20	24	120	119	99.2	70	70	100	83	73	89	50
12	4	22	24	275	274	99.6	20	20	100	89	72	86	45
13	6	24	4	210	203	96.7	70	70	100	88	79	74	56
14	1	24	8	50	48	96	20	19	95	87	76	80	40
15	6	24	15	450	445	98.9				83	71	84	66
16	4	24	24	281	279	99.3	10	10	100	87	74	88	46
17	3	32	4	100	98	98	30	30	100	91	79	83	61
18	1	32	8	50	50	100	20	19	95	87	76	80	40
19	6	32	15	376	376	100	116	116	100	88	75	88	61
20	4	32	24	181	181	100	64	64	100	87	74	88	51
Checks	7			233	16	6.9	205	35	17.1	79	67	81	50

* Dosages of carbon disulfide in pounds per 1000 cubic feet.

† Dosages of hydrocyanic in ounces per 1000 cubic feet.

impair the smoking quality of the cigars. There are many other references which have been reviewed by Runner (*4*), who published in 1919 the results of several years of research on the control of the cigarette beetle. Runner (*4*, pp. 59–60) gave summaries of 34 experiments with dosages of sodium cyanide varying from 1 to 8 ounces per 100 cubic feet. He concluded that it was difficult to kill all insects even with the 8-ounce dosage, and recommended a double fumigation, the second to be carried out about two or three weeks after the first. Runner (*4*, pp. 62–4) gave results of experiments with carbon disulfide and showed an illustration of a fumigation closet for treating cigars. The dosage recommended was 4 pounds to 1000 cubic feet with an exposure of 24 to 48 hours. Runner (*4*, pp. 64–5) also tested carbon tetrachloride and formaldehyde and concluded that dosages of 5 pounds and 2½ ounces, respectively, per 100 cubic feet gave unsatisfactory results.

The foregoing references relate to the fumigation of infested tobacco products, including cigars, but the writers have not seen any papers dealing specifically with a comparison of the effectiveness of various fumigants against the cigarette beetle in cigars.

Apparatus and methods.—In these experiments an attempt was made to provide conditions that would approximate those encountered in the fumigation of naturally-infested cigars. The stages of the cigarette beetle used in these experiments were placed in small gelatin capsules that had been partially filled with pieces of pliable tobacco leaves, usually five insect specimens to each capsule. Several small holes were made in the top of the capsule to facilitate the entrance of the gas and the capsules were then rolled into cigars by a cigar maker. Two capsules containing test insects were placed in each cigar near the center. This method deprived the pupae of the protection normally provided by their cells, but mature larvae were given sufficient time before fumigation to form cells in the tobacco. Long-filler cigars of medium size and with a small tuck (burn end) were used in all experiments and the infested cigars were placed in the bottom row in a loosely filled box containing 50 cigars, the lid of which was held open about one-eighth inch. One box of cigars was fumigated in each experiment and the box was placed on a grating near the floor of the fumigation chamber.

At the end of the exposure the capsules were removed at once from the cigars and placed in pasteboard pill boxes. The first examination of the test insects was made six days after exposure to the gas. Additional examinations were made each 24 hours thereafter if death was not evident through discoloration or collapse of the treated specimens at the previous examination. Observations showed that very few treated specimens revived after the six-day period. Check larvae and pupae kept during the experiments showed an average mortality of 6.9 and 17.1 per cent, respectively. The check and fumigated insects were kept under the same conditions in the laboratory both before and after treatment. The conditions of temperature and humidity that prevailed in each experiment are shown in connection with tables 1 and 2.

All fumigation experiments at atmospheric pressure were conducted in gas-tight containers. These consisted of a steel chamber of 35 cubic

Table 2.—Laboratory experiments in partial vacuum with fumigants against larvae and pupae of the cigarette beetle in cigars,

Table 2.—Laboratory experiments in partial vacuum with fumigants against larvae and pupae of the cigarette beetle in cigars, Tampa, Fla., 1927 to 1928.

Experiment No.	No. Tests	Dosage	Hours Exposure	Initial Vacuum	Total Larvae Used	Larval Mortality		Total Pupae Used	Pupal Mortality		Av. Max. Temp.	Av. Min. Temp.	Av. Max. Relative Humidity	Av. Min. Relative Humidity
						no.	*per cent*		*no.*	*per cent*	*°F*	*°F*	*per cent*	*per cent*
					Chloropicrin									
1	1	3*	3	28†	40	40	100				98	95	55	54
2	1	3	4	28	60	44	73.3				88	80	64	38
3	1	4	4	26	28	27	96.4	32	29	90.6	86	79	74	58
4	1	4.5	3	28	40	39	97.5	10	8	80	94	79	83	52
5	1	4.5	4	28	40	40	100				92	91	65	48
6	1	5	4	26	80	63	78.8	20	20	100	85	77	74	50
7	1	6	2	28	30	30	100				87	83	69	62
8	1	6	4	27	90	75	83.3	80	76	95	86	80	56	43
					Carbon Disulfide–Carbon Dioxice Mixture									
1	1	14.3	2	26	40	29	72.5				86	62	67	65
2	1	14.3	3	20	40	36	90	10	10	100	83	81	75	74
3	2	21.3	3	20	80	78	97.5	20	17	85	91	84	58	49
4	3	28.5	2	20	130	128	98.5	20	17	85	91	87	57	50
5	4	28.5	3	20	160	156	97.5				90	85	63	52
6	2	28.5	4	20	80	80	100	10	10	100	94	85	65	51
7	1	30	2	28	50	50	100				86	81		
8	1	30	4	26	20	18	90	7	6	85.6	80	77	90	80
9	1	35	4	26	55	54	98.2	9	9	100	86	78	80	55
10	1	40	4	26	40	38	95	25	24	96	90	86	62	45
11	1	50	4	27	50	48	96	50	45	90	86	80	47	40
					Hydrocyanic Acid									
1	2	7‡	2	28	45	44	97.8	45	43	95.6	86	79		
2	3	7	4	28	160	159	99.4				87	79	78	61
3	2	10	2	28	110	108	98.2				85	83		
4	4	14	2	28	205	203	99	140	137	97.9	88	83		
5	3	14	4	28	420	420	100	60	60	100	88	81		
6	3	16	4	26	220	219	99.5	10	6	60	86	79	69	50
7	1	18	4	26	50	50	100	10	8	80	86	77	88	54
8	2	20	4	26	112	112	100	8	3	37.5	84	79	82	63
9	1	24	4	26	30	30	100	30	26	86.7	92	83	68	43
10	1	32	4	26	45	45	100	15	14	93.3	89	82	73	50
11	2	40	4	26	87	87	100	33	31	93.9	82	77	91	69
12	4	48	4	26	235	235	100	100	100	100	85	79	63	44
Checks	7				233	16	6.9	205	35	17.1	79	67	81	50

* Dosages in pounds per cubic feet.

† See footnote 1, page 988.

‡ Dosages of hydrocyanic acid in ounces per 1000 cubic feet.

feet capacity and a steel drum with gas-tight cover of 7.19 cubic feet capacity. The larger chamber, used in most of the experiments, is shown in fig. 1.

All fumigations at reduced pressures[1] were conducted in the steel chamber shown in fig. 1. The door of this chamber closed upon a heavy

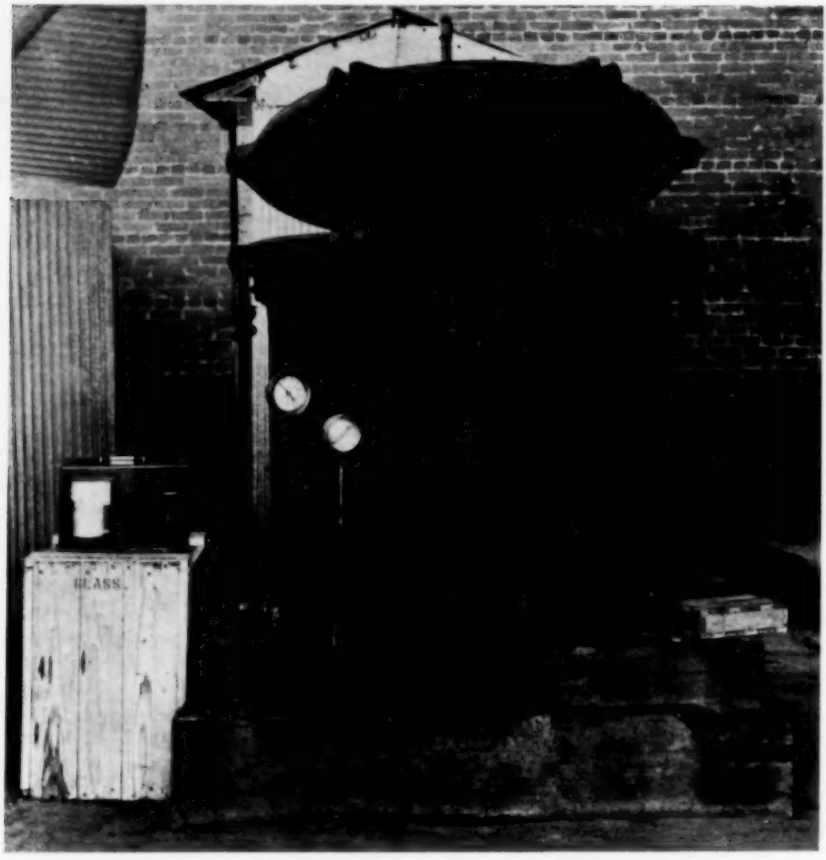

Fig. 1.—Fumigation chamber of 35 cubic feet capacity used in laboratory experiments with various fumigants in the fumigation of cigars.

rubber gasket and was held by six large screw clamps. Reduced pressure was obtained by means of a rotary, single-stage air pump operated by a gasoline engine and was sustained throughout each experiment except in the instance of the carbon disulfide–carbon dioxide mixtures.

[1] The term "fumigation under reduced pressure" is used in this publication instead of "vacuum fumigation." Air pressures within the chamber as given are the actual air pressures therein, expressed in their equivalent inches of mercury, considering the barometric pressure at 30 inches of mercury.

Experiments at atmospheric pressure. CHLOROPICRIN.—A commercial grade of chloropicrin having a specific gravity of about 1.65 was used in these experiments. In preliminary tests this liquid was found to evaporate slowly from shallow receptacles. In the experiments at atmospheric pressure the liquid was poured upon pieces of burlap suspended inside the fumigation chamber. This method of exposure resulted in a more rapid evaporation and a somewhat higher percentage of mortality. Results of 25 tests with chloropicrin at atmospheric pressure are given in table 1.

As shown in table 1, the results obtained with chloropicrin were variable. A complete kill was not obtained consistently with any of the dosages used. Dosages as high as 5 pounds per 1000 cubic feet failed to give complete larval kill with a 15-hour period of exposure.

Cigars fumigated with chloropicrin were examined to determine the effect upon the flavor. The results of these tests were variable and appeared to depend upon the density and moisture content of the fumigated cigars and upon the percentage of relative humidity at the time of airing. A dosage of 1 pound per 1000 cubic feet gave a disagreeable taste which could be detected by the smoker after the cigars had been aired for three days, and in the heavier dosages this was discernible for a longer period.

MIXTURE OF ETHYLENE DICHLORIDE 75 PER CENT AND CARBON TETRACHLORIDE 25 PER CENT, BY VOLUME.—The liquid ethylene dichloride–carbon tetrachloride mixture was allowed to evaporate in a shallow receptacle 1 foot in diameter, placed at the top of the fumigation chamber. A total of 14 experiments were carried out in which cigarette beetle larvae were used. In eight of the tests beetle pupae also were included.

As shown in table 1, a dosage of 20 pounds of the ethylene dichloride–carbon tetrachloride mixture per 1000 cubic feet with an exposure of 24 hours failed to give complete mortality in four experiments. The results indicate that this mixture is unsatisfactory for the fumigation of cigars. The gas passed off from the cigars rather slowly and for several days after fumigation an objectionable taste could be detected when the cigars were being smoked.

CARBON TETRACHLORIDE.—The liquid carbon tetrachloride was allowed to vaporize from a shallow receptacle 1 foot in diameter, placed at the top of the fumigation chamber. Thirteen experiments were conducted.

As indicated in table 1, carbon tetrachloride at a dosage of 35 pounds per 1000 cubic feet with an exposure of 24 hours gave incomplete kills of test insects. This heavy dosage resulted in a pronounced flavor in the cigars which was evident in smoking after the cigars had been aired for several days. The results indicate that carbon tetrachloride is not a satisfactory fumigant for cigars.

CARBON DISULFIDE.—In the experiments at atmospheric pressure with carbon disulfide the fumigant was allowed to vaporize from a shallow receptacle 1 foot in diameter, placed at the top of the fumigation chamber, except that in experiment 11 and in two tests in experiment

3, the chemical was vaporized by means of hot-water heat. When heat was used, a dosage of 4 pounds per 1000 cubic feet was vaporized in about two minutes. Fifty-nine experiments were conducted.

The results, as indicated in table 1, show that carbon disulfide used at dosages of 10, 8 and 6 pounds per 1000 cubic feet with exposures of 8, 15 and 24 hours, respectively, gave complete kills of all larvae and pupae except that one larva out of 419 survived the 8-pound–15-hour combination in experiment 9. A small number of eggs and adults included in the experiments, but not shown in the table, were killed by the dosage–time combinations mentioned.

The gas left the cigars rapidly when the latter were exposed to the air and no disagreeable odor or flavor remained. The results indicate that this fumigant is satisfactory for cigars, but, owing to its inflammable and explosive nature when mixed with air, most fire insurance companies have prohibited its use. A few insurance companies still permit its use when certain precautionary measures are complied with.

Liquid Hydrocyanic Acid.—The liquid hydrocyanic acid used in these experiments was a commercial product said to contain not less than 96 per cent of hydrocyanic acid. In these experiments the liquid was poured into the fumigation chamber through a short iron pipe. Fifty-nine tests were conducted.

It will be noted in an examination of table 1 that a dosage of 24 ounces of liquid hydrocyanic acid per 1000 cubic feet, with an exposure of four hours (experiment 13), produced a high mortality in six tests, but that it was difficult to establish any time–dosage combination that would result consistently in complete mortality. The evidence indicates that hydrocyanic acid gas does not penetrate cigars very readily and that a dosage of 32 ounces per 1000 cubic feet with an exposure of 15 to 24 hours is required for satisfactory results. A relatively small number of eggs included in experiments 3, 4 and 17, but not shown in the table, were killed as a result of the treatments, indicating that this stage of the insect is less resistant than the larval or pupal stages.

Inasmuch as large quantities of cigars are treated with hydrocyanic acid, it is evident that this material does not leave any objectionable odor in the product.

Experiments under reduced air pressures. Chloropicrin.—Eight experiments were conducted in the vacuum chamber in which larvae and pupae of the cigarette beetle were fumigated with chloropicrin. The chloropicrin, which was of the same grade as that used in experiments at atmospheric pressure, was drawn into the evacuated chamber through at atomizing nozzle.

As indicated in table 2, the results obtained with chloropicrin were variable. An incomplete kill was obtained with a dosage of 6 pounds per 1000 cubic feet and a four-hour period of exposure with a 27-inch vacuum (experiment 8). Chloropicrin in partial vacuum probably is unsatisfactory as a cigar fumigant and leaves a bad flavor in the cigars.

Carbon Disulfide–Carbon Dioxide Mixture.—In this series of experiments the liquid carbon disulfide was drawn into the evacuated chamber through an atomizing nozzle. To obviate the possibility of an

explosion, carbon dioxide was admitted along with the charge of carbon disulfide. After the dosage of carbon disulfide was admitted the pressure was raised at once to atmospheric pressure with additional carbon dioxide. A total of 18 tests were conducted.

It will be noted in an examination of table 2 that relatively high kills were obtained with this mixture under reduced pressures. Complete kills were not obtained, however, at a dosage of 50 pounds per 1000 cubic feet with an exposure of four hours and an initial vacuum of 27 inches (experiment 11).

HYDROCYANIC ACID.—The liquid hydrocyanic acid used in the fumigations under reduced pressures was similar to that used in the experiments at atmospheric pressure. It was drawn into the evacuated chamber through an atomizing nozzle and no air was admitted except the small amount drawn in with the liquid. In a series of comparative experiments with sustained low pressure and high pressure described in another paper by the authors (*1*), the sustained low pressure method appeared to be the more effective. Twenty-eight tests were conducted.

As indicated in table 2, liquid hydrocyanic acid at a dosage of 7 ounces per 1000 cubic feet with an exposure of two hours at low pressure produced high mortality in larval and pupal stages of the cigarette beetle. In preliminary experiments, in which conditions were similar to those described herewith, it was found that relatively high mortality was obtained through the use of 2.1 ounces per 1000 cubic feet with an exposure of two hours at low pressure. Despite this high toxicity, it will be noted that it was necessary to increase the dosage to 3 pounds per 1000 cubic feet and the period of exposure to four hours with a 26-inch vacuum (experiment 12) before complete kills could be obtained consistently. A relatively small number of eggs included in experiments 1, 2, 3 and 4, but not shown in the table, were killed by the treatments.

Summary.—This paper describes a series of fumigation experiments with various fumigants for the control of the cigarette beetle in cigars. Study of the absorption and adsorption of the fumigants by the cigars was not included in this work. The results show the comparative effectiveness of the various materials and indicate promising lines for further investigation although they are not considered complete enough to form a satisfactory basis for control recommendations.

The conclusions formed with regard to the fumigants tested are as follows:

Chloropicrin, tested at atmospheric pressure and at reduced pressure, did not give a satisfactory kill of the cigarette beetle in cigars and the compound had a tendency to produce a disagreeable flavor in the product.

A mixture of ethylene dichloride 75 per cent and carbon tetrachloride 25 per cent, and carbon tetrachloride alone, tested at atmospheric pressure, were found to be unsatisfactory as cigar fumigants. The mortality was not sufficiently high and these fumigants had a tendency to leave a disagreeable flavor in the cigars.

Carbon disulfide tested at atmospheric pressure at dosages of 10, 8 and 6 pounds per 1000 cubic feet with exposures of 8, 15 and 24 hours, re-

spectively, gave complete kills of all stages of the cigarette beetle except that one larva out of 419 survived with the 8-pound-15-hour combination. Heavy dosages of this fumigant did not give complete kills with a four-hour period of exposure under the conditions of our experiments, even when assisted by low pressure. The gas left cigars rapidly upon exposure to the air and there was no perceptible change in the flavor.

The experiments with liquid hydrocyanic acid gas at atmospheric pressure indicated that this gas does not penetrate cigars very rapidly and that a dosage of 2 pounds per 1000 cubic feet with an exposure of 15 to 24 hours is required for complete kills. While experiments with liquid hydrocyanic acid at reduced pressure indicated relatively high mortality with a dosage of 7 ounces per 1000 cubic feet and a two-hour exposure period, it was found necessary to increase the dosage to 3 pounds per 1000 cubic feet and the period of exposure to four hours before complete kills could be obtained consistently with a vacuum of 26 inches. The gas did not leave any perceptible odor in the product.—9-8-36.

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FUMIGATING SWEET POTATO SEED WITH PDB TO CONTROL SWEET POTATO WEEVIL

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Entomologists who early devoted attention to the sweet potato weevil, *Cylas formicarius* (Fab.), recognized the importance of treating stored sweet potatoes to rid them of infestation. Conradi (*2*) experimented with carbon disulfide and stated that all stages of the insect could be killed, but did not recommend its general use upon farms. Newell (*4*) referred to Conradi's experiments and advised fumigating in tight compartments or barrels. Chittenden (*1*) also recommended carbon disulfide, but cautioned against possible injury to germination and increase in rot and decay. Hinds (*3*) recommended disinfecting storage houses by burning sulfur in them. Despite the consideration given to fumigation, comparatively little experimental work was conducted and the literature upon fumigation is very limited.

In eradication and control work by the writers, the elimination of

infested seed or planting stock was recognized as one of the most important measures in controlling the sweet potato weevil. During the course of this work occasions arose where some preliminary experimental fumigation could be done. The first tests with PDB (paradichlorobenzene) were conducted at Biloxi, Miss., in 1925. These were small experiments and were conducted without replication and without recording the effect upon germination.

Four preliminary experiments were conducted in the following manner: in each of four 50-gallon oak barrels 1 bushel of heavily infested sweet potatoes was placed. In two of the barrels sheets of newspaper were placed flat on top of the potatoes, with 1 ounce of PDB in

Fig. 1.—Barrels used in fumigation experiments.

one barrel and 2 ounces applied in the second barrel. The barrels were closed by placing oilcloth over them and driving hoops down over the tops.

The other two experiments were set up at the same time, likewise using 1 and 2 ounces of PDB, respectively, to the barrel; but instead of using the paper and oilcloth on the barrels, the potatoes were covered with a layer of pine needles, on which the PDB was sprinkled, and the barrels closed by adding 6 inches of soil on top of this. All four experiments ran for 28 days. At the conclusion of the experiments the potatoes were cut and all stages of the insect examined. No live specimens were found. There was no indication that rot or decay had increased in the potatoes.

Later, another series of four experiments was conducted in a manner similar to the first except that the potatoes in all four barrels were covered with pine needles and soil. In two of these experiments one-fourth bushel of potatoes was used in each barrel, one being treated with 1 ounce of PDB and the other with 2 ounces. In each of the other two experiments each barrel contained 1 bushel of potatoes, one of which received 1 ounce of PDB and the other 4 ounces. The exposure for these

four tests was 22 days. In all four experiments all specimens of the sweet potato weevil were killed. Potatoes in the first three experiments were apparently uninjured, but in the fourth experiment, where 4 ounces of PDB per bushel were used, the potatoes were injured by the treatment. There were 13 sound potatoes, 32 partially sound, and 80 totally rotten potatoes.

All the insects were killed by PDB in these preliminary experiments, but the fumigated potatoes retained an objectionable odor for an indefinite period. Therefore, all subsequent fumigation tests were limited to seed potatoes, since an objectionable odor or an unpleasant taste in such potatoes would not interfere with their use for seed.

Experimental technique.—During 1933, 1934 and 1935, additional experiments were outlined to determine the minimum dosage and exposure that could be applied to potatoes to obtain satisfactory mortality of the weevils, and, in addition, to determine the effect upon germination. Three types of fumigation experiments were conducted, *viz.*, in barrels, in dirt storage banks, and in seed beds. Thermometers were placed in the barrels and storage banks. A brief description of the methods employed in each type is given.

Fig. 2.—Series of seed storage banks used in fumigation experiments.

Barrels.—In the majority of these tests 50 pounds of sweet potatoes were placed in each of the series of 200-pound sugar barrels, fig. 1. In some of the tests, however, 150 pounds of potatoes, or enough to fill the barrels, were used. Approximately 4 inches of pine needles were placed over the potatoes, and the PDB was sprinkled evenly on them and then covered with 4 inches of soil. The barrels were placed in an open garage or in an outdoor insectary, where they were protected from rain but not from other climatic conditions.

Dirt Storage Banks.—Regular conical, dirt storage banks, such as are in common use on small farms, were used in this set of experiments, fig. 2. Fifty pounds of sweet potatoes were used in each bank, these being covered with pine needles and then by approximately 4 inches of soil. Before covering the top of the bank the required quantity of PDB was

sprinkled on the pine needles and soil above the potatoes, and the bank was then completed or capped over by adding the remainder of the soil, fig. 3.

SEED BEDS.—Fifty pounds of sweet potatoes were used in each of these experiments, and they were bedded in the usual manner practiced

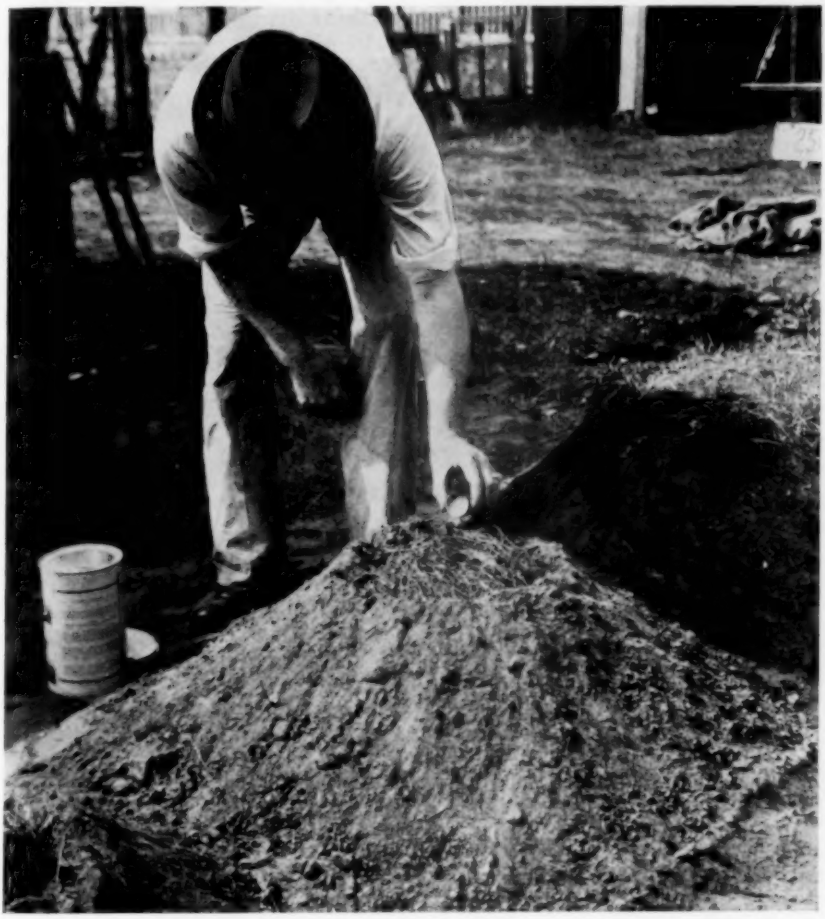

Fig. 3.—Method of applying PDB to seed storage bank.

upon farms. After the potatoes were spread out in the bed they were covered with 1 inch of soil and the PDB sprinkled evenly on this above the potatoes, fig. 4. Three more inches of soil were added to complete the bedding process.

In all cases these experiments were replicated, and check lots of potatoes were maintained with the treated lots in order to obtain informa-

tion upon the effect of the fumigation upon the potatoes and upon germination.

METHOD OF HANDLING POTATOES AND SPECIMENS.—From 4 to 10 pounds of infested potatoes were used in each of the above tests, the exact quantity varying according to the scarcity of material or the degree of infestation. Enough infested potatoes were used, however, to assure sufficient specimens of the weevil for examination. At the con-

Fig. 4.—Applying PDB to seed bed.

clusion of the fumigation period the infested potatoes were cut and all insects examined for mortality. Inasmuch as the procedure was to cut all the infested potatoes used in each experiment, the results are based upon examination of total specimens in an experiment and not upon a random sample. The remainder of the potatoes, consisting of those that were not infested, were then used for bedding to obtain germination records, fig. 5. In the seed-bed experiments, however, the uninfested potatoes remained in the beds for germination records. The specimens of the weevils taken from the potatoes in the treated lots and in the check lots were placed in 4-ounce tin salve boxes on moist blotting

paper and examined daily for 72 hours, to determine definitely whether they were alive or dead.

Weevil mortality.—Use of 1 ounce of PDB per 50 pounds of sweet potatoes in barrels with an exposure of 21 days, and 1 ounce per 50 pounds of potatoes with an exposure of 28 days, or 1.5 ounces per 50 pounds of potatoes with an exposure of 21 days in storage banks, gave 100 per cent mortality of the weevils. With reduction in the quantity of PDB applied or in duration of exposure the fumigation did not give satisfactory results. Dosages and periods of exposures that were effective in barrels and storage banks were insufficient in seed beds, table 1.

Effect of PDB upon potatoes.—The sweet potatoes used in the experi-

Fig. 5.—Plant beds used for checking germination of fumigated seed.

ments discussed in this paper absorbed PDB gas and retained an objectionable odor for an indefinite period after treatment. This feature has, for the time being at least, eliminated the possibility of recommending the fumigation of sweet potatoes with this chemical when they are intended for food. The fumigation apparently caused a reduction or retardation of soft rot, *Rhizopus nigricans* Ehrh., since in practically every experiment where there was any evidence of rot it was found to a greater degree in the check potatoes than in the treated lots. Although in some instances a slight degree of dessication was observed in the fumigated potatoes, this did not produce an appreciably harmful effect upon germination. In the fumigated seed used in these tests there was a general tendency toward retardation of germination, and there was wide variation in some cases in the relation of the treated and check lots to their respective productivity, but no significant reduction in the number of plants eventually produced by the treated lots is shown in the series as a whole. The data obtained in the tests are given in table 2.

Temperature during fumigation.—Temperatures ranging from 60° F upward are usually considered best for fumigation. However, in some of

Table 1.—Larvae, pupae and adults of the sweet potato weevil killed by fumigation with PDB at various dosages and periods of exposure in barrels, storage banks and seed beds at Biloxi, Miss.*

Ounces Dosage	Days Exposure	No. Larvae Dead	No. Larvae Alive	No. Pupae Dead	No. Pupae Alive	No. Adults Dead	No. Adults Alive	Per Cent Mortality
			Fumigation in Barrels					
1	14	26	0	13	0	12	10	83.6
1	7	18	56	12	2	24	4	46.5
1.5	14	44	9	9	0	11	0	87.7
2	7	4	13	4	2	9	0	53.1
2	14	59	5	9	0	5	0	93.6
.75	21	29	1†	9	0	22	0	98.4
1	21	15	0	14	0	8	0	100
1	18	39	6	3	0	12	0	90
.75	24	53	5	35	6	11	3	87.6
3	21	– 4‡	0	3	0	1	0	100
		–15¶	0	15	0	2	0	100
4.5	21	–17‡	0	11	0	8	0	100
		–15¶	0	0	0	0	0	100
Check	21	– 1‡	3	0	1	0	9	7.2
		0¶	0	1	1	1	9	16.7
			Fumigation in Dirt Storage Banks					
1	21	292	3	125	0	31	0	99.3
1	21	399	13	27	2	13	0	96.7
1	21	346	1	12	0	14	0	99.7
Check	21	2	56	2	212	2	120	1.5§
2	21	585	0	98	0	108	0	100
2	21	419	0	6	0	101	0	100
2	21	379	0	142	0	49	0	100
Check	21	3	57	16	258	2	346	3.1§
1	28	1	0	4	0	15	0	100
1	28	1	0	0	0	26	0	100
1	28	2	0	7	0	42	0	100
Check	28	3	7	1	2	3	7	30.4
1.5	21	12	0	36	0	46	0	100
1.5	21	1	0	2	0	38	0	100
1.5	21	6	0	19	0	79	0	100
Check	21	0	4	1	1	1	13	10§
			Fumigation in Seed Beds					
2	21	25	0	15	2	25	0	97
2	21	16	2	5	0	10	0	93.9
2	21	37	5	8	1	15	0	90.9
Check	21	8	25	4	16	7	25	22.9§
3	21	21	0	13	0	22	0	100
3	21	41	2	25	0	16	0	97.6
3	21	20	0	11	0	19	0	100
Check	21	0	13	4	4	9	21	25.5§
1	21	13	0	23	0	30	9	88
1	21	6	0	15	0	28	10	83
1	21	2	1	11	0	6	19	48.7
Check	21	1	0	1	1	10	25	31.6§

* Fifty pounds of sweet potatoes were used in each test, except that in the tests with the 3-ounce and 4.5-ounce dosages in barrels, and in the accompanying check, 150 pounds of potatoes were used.
† This specimen dead at end of 96 hours.
‡ Top of barrel.
¶ Bottom of barrel.
§ Some of specimens dead from injuries inflicted in removing them from the potatoes.

these experiments low temperatures were experienced. During one set of experiments the temperature was below freezing, reaching 18° F on two successive nights and on two other successive nights 25° F. In the presence of such unusually low temperatures for this locality, 100 per cent weevil mortality was obtained. Ordinarily the temperature in the fumi-

Table 2.—Number of sweet potato plants produced from seed fumigated with PDB at various dosages and periods of exposure, in barrels, storage banks and seed beds, at Biloxi, Miss.

Ounces Dosage per 50 Lbs. Potatoes	Days Exposure	Pounds Potatoes Used	No. Plants Produced at First Pulling		No. Plants Produced During Season	
			Total	Per Pound	Total	Per Pound
Germination in Barrels						
1	7	42	758	18.04	2543	60.55
2	7	42	130	3.1	2627	62.55
Check	7	42	1028	24.48	3018	71.86
1	14	42	602	14.33	2179	51.88
1.5	14	42	119	2.83	2025	48.21
Check	14	42	728	17.33	2168	51.62
2	14	42	367	8.74	1654	39.38
Check	14	42	467	11.12	1471	35.02
1	18	42	154	3.67	1174	27.95
Check	18	21	170	8.1	594	28.28
.75	21	42	635	15.12	2048	48.76
1	21	42	120	2.86	2184	52.
Check	21	42	302	7.19	1124	26.76
1	21	25	163	6.52	577	23.08
1.5	21	25	22	.88	245	9.8
Check	21	25	499	19.96	1218	48.72
.75	24	42	37	.88	1545	36.78
Check	24	21	165	7.86	598	28.47
Germination in Dirt Storage Banks						
1	21	25	75	3.	696	27.84
2	21	25	204	8.16	718	28.72
Check	21	25	185	7.4	505	20.2
1.5	21	25	555	22.2	1183	47.32
Check	21	25	342	13.68	1117	44.68
1	28	25	575	23.	982	39.28
Check	28	25	456	18.24	827	33.08
Germination in Seed Beds						
2	21	46	780	16.96	2444	53.13
2	21	46	791	17.2	2338	50.83
2	21	46	357	7.76	2397	52.11
Check	21	46	690	15.	2432	52.87
3	21	46	538	11.7	2690	58.48
3	21	46	560	12.17	2436	52.92
3	21	46	112	2.43	2331	50.67
Check	21	46	931	20.24	2399	52.15
1	21	46	536	11.65	1701	36.98
1	21	46	569	12.37	2048	44.52
1	21	46	767	16.67	1951	42.41
Check	21	46	640	13.91	1909	41.5

gated barrels, storage banks and seed beds was several degrees higher than that of the surrounding atmosphere. In view of the low temperatures encountered during these experiments, satisfactory results may be expected at any temperature that may occur ordinarily in the infested area, during the period when such fumigation should be performed.

Summary.—Experiments conducted thus far at Biloxi, Miss., have shown: first, that 100 per cent of all stages of the sweet potato weevil can be killed by fumigating seed in barrels with 1 ounce of PDB per 50 pounds of potatoes for 21 days, and in storage banks with 1.5 ounces of

PDB for 28 days or 2 ounces of PDB for 21 days; second, that germination is retarded slightly but not, on the whole, reduced; third, that soft rot, *Rhizopus nigricans* Ehrh., is reduced or prevented by fumigation; fourth, that the use of PDB is so economical that it may be employed even by growers operating on a small scale.—9-10-36.

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DECREASE IN EFFECTIVENESS OF STORED PYRETHRUM DUSTS

AS SHOWN BY BIOLOGICAL TESTS WITH THE CELERY LEAF TIER IN THE LABORATORY

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It is seldom possible to predict accurately an insect outbreak or to gauge its intensity and duration. As a result of this situation, the farmers and insecticide supply houses often find it difficult to supply the necessary insecticides on short notice unless a quantity has been kept over from year to year. In addition, there is usually a certain quantity left over after the end of the crop season. When the insecticides concerned are those of mineral origin, such as the arsenical and fluorine compounds, this is merely a question of having capital tied up, but with the organic insecticides, such as pyrethrum, tobacco, derris, and cubé, deterioration may be responsible for a considerable monetary loss.

The problem of the storage of pyrethrum is quite important in the Sanford, Fla., celery-growing area where the use of this material is necessary in the control of the celery leaf tier, *Phlyctaenia rubigalis* Guen. This insect is present every season, but it is only during seasons which are warmer than the average that serious outbreaks occur. Even then, sudden periods of cold weather may delay development of certain stages of the insect, making it possible to harvest the crop without the necessity of applying control measures. Likewise, periods of sudden high temperatures may accelerate development and produce serious leaf tier damage to mature celery within a few days. Under these conditions of uncertainty the supply houses and the farmers hesitate to keep on hand a very large supply of pyrethrum which may not be used for one or two seasons and which might deteriorate materially during that time. When an outbreak does occur, the acreage concerned is usually quite large and several tons of pyrethrum dust are used within a short time.

Confronted with this situation, it was deemed advisable to study under Florida conditions the effect of storage on pyrethrum dust, as far as its toxicity to the celery leaf tier under laboratory conditions was concerned.

Method and materials.—Many of the studies which have been made by other investigators on the deterioration of pyrethrum flowers have been based on the deterioration resulting from artificial exposure to varying conditions of sunlight, air and moisture. The powders have been alternately moistened and dried or exposed in thin layers to sunlight, rainfall and other weather conditions. In the studies herein reported it was desired to simulate conditions as found on the average farm. One-pound samples of various pyrethrum dusts and mixtures have been kept at the Sanford laboratory in an open room for several years. Each sample is in a heavyweight paper bag within a friction-top can. One series, termed "closed containers," has the top of the bag creased and the friction top closed tightly. The "open container" series has the friction top removed and the bag open, exposing the upper surface of the dust to the air and whatever sunlight is present.

At the time these samples were stored (1930–33), the only chemical analyses available giving the amount of pyrethrins were those supplied by the manufacturer. These samples were purchased from the same firm, and were guaranteed to contain not less than .9 per cent pyrethrins at the time of storage.

Laboratory tests have shown that the use of the following testing technic gave satisfactory results which would make possible reliable comparisons of the effectiveness of different materials. Ten nearly mature larvae of the celery leaf tier were directly exposed in a precision dusting apparatus to settling dust clouds sufficient to deposit approximately .3 mg. of dust per square inch, food was added, and the containing petri dish was set aside for examination after 24 and 48 hours. Preliminary tests had shown that the use of small larvae resulted in almost complete mortality with any pyrethrum dust, but that with large larvae comparisons could be made by this method which approximately paralleled the results of field control tests. Five replications were made, at three different dates, giving a total of 15 replications, using 150 larvae for each material.

The samples selected from the many on hand for test during the winter of 1933–34 were as follows:

(1) Fresh pyrethrum powder received December 1933.

(2) A mixture of fresh pyrethrum powder and tobacco dust, 50 per cent each by weight.

(3) Pyrethrum powder stored for one year in closed container.

(4) Pyrethrum powder stored for one year in open container.

(5) Pyrethrum powder stored for two years in closed container.

(6) Pyrethrum powder stored for three years in closed container.

(7) Pyrethrum–tobacco mixture stored for one year in closed container.

(8) Pyrethrum–tobacco mixture stored for one year in open container.

(9) Pyrethrum–tobacco mixture stored for two years in closed container.

(10) Pyrethrum–tobacco mixture stored for two years in open container.

It was decided to test tobacco dust as a diluent instead of lime, clay or sulfur, because tobacco dust has been the diluent used almost exclusively in the Sanford area. None of the tobaccos used as diluents had, alone, a measurable effect on the large larvae. Tightly closed barrels of pyrethrum are often kept for two years at warehouses and sometimes a farmer will have on hand an unopened barrel, and so dusts kept in closed containers were tested for three seasons. As a rule, a partially emptied barrel will be used during the second season for some insect pest, and so pyrethrum in open containers was tested only after exposure for one year. Our recommendations have been to mix no more of a diluted dust than would be used at any one time. The farmers, however, do keep the mixtures over, usually in loosely covered or open barrels, and insecticide supply houses may mix a greater quantity than can be disposed of in

Table 1.—Percentage of mortality of mature celery leaf tier larvae resulting from use of stored pyrethrum dusts.

Period of Storage	Pyrethrum Dusts		Pyrethrum-Tobacco Mixtures	
	Closed Container	Open Container	Closed Container	Open Container
Fresh	95.3		86.6	
1 year	97.3	88.6	83.3	72
2 years	88		81.3	65.3
3 years	84.6			

Difference in percentage required to show significance: 11.3

any one season. Thus it was decided to test the pyrethrum–tobacco mixture in both open and closed containers for one and two years.

Results.—The data obtained in these tests are shown in table 1.

Upon analyzing the data for which these percentages of larval mortality are the summation, the following facts were brought out:

(1) The odds are 50 to 1 that a difference of 11.3 per cent is significant.

(2) At these odds, there was no significant difference between the fresh pyrethrum and any of the samples of undiluted pyrethrum stored for one, two and three years in closed containers.

(3) No difference was conclusively demonstrated between the fresh undiluted pyrethrum and the fresh pyrethrum–tobacco mixture.

(4) The pyrethrum–tobacco mixtures stored in closed containers for both one and two years did not differ significantly from the freshly mixed pyrethrum–tobacco, but the samples stored in open containers were significantly inferior to the corresponding samples stored in closed containers.

(5) The sample of undiluted pyrethrum stored for one year in an open container did not differ significantly from the sample stored for that length of time in a closed container, or from the fresh sample.

Discussion.—The larvae were confined in the same petri dish in which they were treated, with an abundance of untreated food. They could

at once crawl upon the food and not be in contact with the pyrethrum which had settled upon the bottom of the cage. At the time of the first examination (24 hours after treatment) a few larvae could be found which were disorganized. By the second day all such larvae were either unquestionably dead or had recovered from the effects of the dust.

While it would be quite desirable to correlate the results of biological tests with chemical analyses of the samples, such was not the object of this experiment. It was desired only to obtain indications regarding the effect of storage upon commercial grades of pyrethrum powders in relation to their possible effectiveness against the celery leaf tier in the field.

That no significant differences were shown among the undiluted pyrethrum dusts would indicate that such dusts would still be effective in field control. Likewise, there was no significant difference between the fresh pyrethrum–tobacco mixture (86.5 per cent) and the mixtures stored for one and two years in closed containers (83.3 and 81.3 per cent respectively), but the differences between these mixtures stored in closed containers and the corresponding ones in open containers (72 per cent for one year and 65.3 per cent for two years) were significant. These results indicate that the practice of storing pyrethrum powder mixed with tobacco dust in open containers results in definite deterioration. Such materials should be used soon after mixing unless stored in a very tight container.

Summary.—Laboratory biological tests with stored pyrethrum dusts indicate that undiluted pyrethrum would be effective in the field when stored for as long as three years in closed containers. The commonly used pyrethrum–tobacco mixture should be effective when stored for one or two years in closed containers, but a definite deterioration could be expected when stored in open containers, as is a common practice among farmers in the Sanford, Fla., area.—8-15-36.

FLY CONTROL ON A & M FARMS, STILLWATER, OKLA.

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With its teaching and experiment station work the school of agriculture of Oklahoma A. & M. College operates several large farms, some of which are adjacent to the college buildings. There are six large barns on these farms, in addition to a miscellaneous number of sheds where several hundred head of cattle, swine, horses and sheep are kept. There are also several large flocks of poultry. Concentration of this large number of animals and flocks of poultry and the location of the barns in close vicinity to the college campus has created an acute fly problem which is not only of importance to the campus offices and laboratories, but to the barns as well. Further, location of the barns within a short distance of a residential part of the city also causes flies to be unusually numerous and troublesome in that part of Stillwater. It was therefore of

importance that steps be taken to abate this nuisance if possible. Following the practice of previous years, the Department of Entomology was asked to take charge of this work in 1935, and a special fund was set aside for this purpose. Work was started June 15 and was in full swing within two weeks. It was decided to attack the problem from five angles as follows: (1) proper disposal of breeding media, (2) chemical treatment of breeding media, (3) trapping adult flies, (4) spraying, and (5) poisoning flies.

It was recognized at the start that to secure best results full cooperation of the departments concerned was needed, and since the department having the largest number of barns was actively interested in promoting this campaign, this was not difficult to obtain. A student was selected to take charge of this work and he was assisted by two CCC men. A letter was written to the different department heads, acquainting them with the measures that were going to be undertaken in the campaign. A special report form was mimeographed on which was given the following information: location of breeding media, extent of its infestation, treatment recommended, treatment given by the inspector, number of fly traps in operation, total catch and average catch per trap per day. At the bottom of the report was a note as to whether the fly population had increased or decreased since the last inspection. This blank was filled out for each inspection of each barn or property where the traps were located, and if possible was signed by the farm superintendent, but always signed by the inspector. This report was made out in duplicate, one copy for the files of the Department of Entomology and the other for the head of the department operating the barns. It was important to keep the extent of the fly infestation in the different barns an entirely confidential matter, known only to the Department of Entomology and to the department operating the barn. These reports were made out two or three times a week, or for every inspection made, and were mailed as soon as possible after the inspection had been completed.

Proper disposal of breeding media.—A preliminary survey showed that flies were breeding in a great many different places, such as in the soil beneath temporarily stored manure, in piles of refuse, in droppings in the various animal pens, in the corrals, wherever the manure had been allowed to stand for some time, etc. It was recommended that wherever possible the manure be hauled away every day and spread on the fields. For the larger departments this was already being done to a very large extent; in other cases arrangements were made to do the work. The college also has a manure pit in one of the fields at some distance from the campus which was being used by one of the departments. It was necessary to arrange to screen this pit. Proper disposal of breeding media was believed to be the most important part of the fly-control campaign and since each barn and premise was inspected at least three times a week, within a comparatively short time the greater bulk of the standing manure piles had been removed and each day's collection was being taken care of within 24 hours.

Treatment of breeding media.—Wherever it was not feasible nor practical to haul away manure, it was treated. The two insecticides con-

sidered for this were hellebore and borax as recommended by Cook (*2*). The former was preferred because it was not toxic to plants grown in soil fertilized with it. The hellebore proved to be ineffective both by laboratory and field tests. The strength used was one-half pound per 10 gallons of water for approximately 8 bushels of manure. Borax was therefore used whenever the manure was not to be used for fertilizer. Laboratory tests proved it to be an effective larvicide but in practice spraying was not satisfactory due to the large amount of spray needed for a comparatively small amount of manure. Therefore the manure was liberally treated with the borax powder which was then sprayed with water. This proved effective. Treatment with borax was sometimes made by the inspector, but more often by the men working at the different barns. The inspector recommended where the treatments be made and checked on their effectiveness.

Trapping.—The department had 24 large cylindrical fly traps manufactured as recommended by the federal Department of Agriculture (*1*). The number of these traps set in the different barns depended upon the size of the barn and the acuteness of the fly situation there. Some of the barns required only one, others as many as six. These were located where the greatest fly population existed and where they were protected from being overturned by the animals. After a number of preliminary tests had been made it was found that the following bait formula was the most satisfactory as far as catching the greatest number of flies was concerned:

Wheat bran	$3\frac{1}{4}$ lbs.
Alfalfa meal	$1\frac{3}{4}$ lbs.
Yeast	2 cakes
Water	5 quarts
Diamai	25 cc.
Black strap molasses	1 qt.
Additional water to keep moist	

This bait was effective only when kept moist, so that during the peak of the fly season the traps were examined every day and the bait watered. The bait was changed and the traps were emptied two or three times a week. The flies which were trapped were measured by volume, each pint being equivalent to approximately 8500 flies.

There is no doubt that these fly traps aided very materially in reducing the fly population. Approximately 9,786,000 flies were taken in these traps. In addition to destroying great numbers of flies, the traps made it possible to keep a record of the fly population, and this gave a clue to the effectiveness of the fly-control campaign. They also had an important psychological effect on the barn superintendents. To determine the species of flies trapped, sample lots were taken from representative traps throughout the season. These are being studied and the species will be identified as soon as possible. Analysis of 51 samples examined so far shows that 93.8 per cent are *Musca domestica*, the common house fly. Of 4684 house flies examined, 68.72 per cent are females.

Spraying.—The department also furnished fly spray to be used in the

different barns participating in the fly-control campaign. In most cases the barn superintendent was in a better position to spray the barns than we were, and also, as in the case of the Dairy department, it was necessary to spray at certain times to avoid giving the milk a strong taste of the fly spray. The spray used had pyrethrum extract as its killing agent and was prepared by the department at the rate of 1 gallon of pyrethrum extract[1] to 20 gallons of water-white kerosene. It was noticed by the

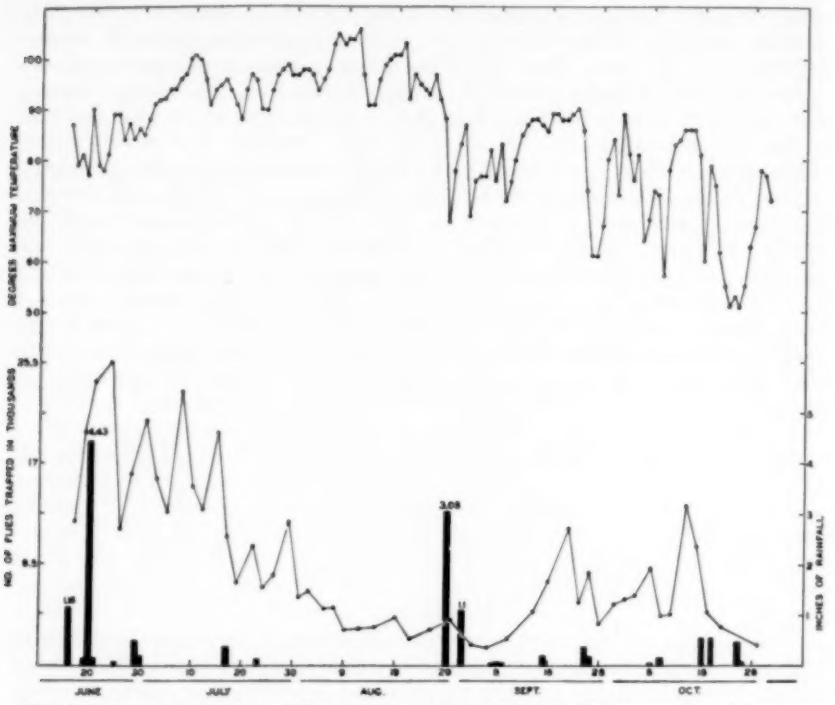

Fig. 1.—Average number of flies taken per trap, daily maximum temperatures, and rainfall, Stillwater, Okla., 1935.

catch in the fly traps that whenever fly spray was used more or less regularly, the fly population dropped considerably.

Poisoning.—The poison utilized was a milk–formalin mixture in the following proportions:

Milk and water in equal proportions.....1 pint
Molasses sufficient to sweeten.....(4 oz. per gallon)
Concentrated formaldehyde (40%)..2 or 3 teaspoonfuls

This poison was placed in tin pie pans which were set at different points in the barns where they were protected from poultry and animals and where they would kill the most flies. A number of observations showed

[1] *Basic Pyrethrum Extract 191.* Manufactured by John Powell and Co., 114 East 32nd St., New York, N.Y.

that the poison in these pans killed large numbers of flies. They supplemented the fly traps especially in places where it was possible to locate only one trap where several should have been.

Results of campaign.—The average catch per trap for the season is shown in fig. 1. By June 24 an average of 25,500 flies had been taken in each of 22 traps which had been in operation since June 21, the previous date of examination. Wide fluctuations were observed in the average number of flies trapped but the trend was downward, particularly after July 15. On August 29 a total of 3.08 inches of rain fell, the first in 36 days. This ended the hot dry weather and showers were more frequent afterwards. Probably as a result of the cooler weather and increased moisture there was a late-season increase in the fly population which

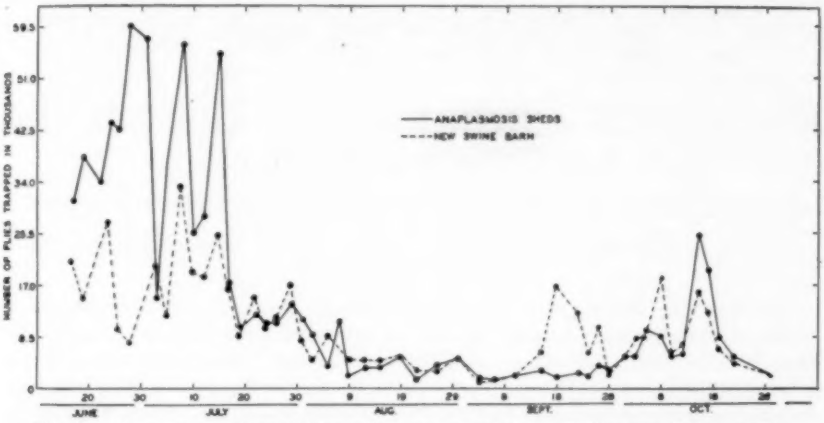

Fig. 2.—Average number of flies taken at two stations, Stillwater, Okla., 1935.

reached two rather definite peaks, namely September 22 and October 15. At the second and higher peak, an average of approximately 13,430 flies was caught per trap.

While no doubt more favorable weather conditions brought about part of this increase, at least part was due to a general relaxation of other control measures following the long period when flies were scarce. That it is possible to reduce the fly population despite favorable fly-breeding climatic conditions is shown in fig. 2. From September 15 to 26 there was a decided increase in the fly population at the new swine barn. This did not occur at the anaplasmosis sheds where treatment of manure was being continued. Both stations, however, showed increases during October, but the anaplasmosis sheds did not show a marked increase until October 15. It is believed that stopping the borax treatment of manure caused part of the increase at the latter station.

Conclusions.—Since there were no barns where fly-control measures were not being carried out, the effect of the campaign cannot be judged in terms of a reduction of the fly population over what would have occurred without these measures. There are, however, many indications

that the campaign was successful. At several points trapping was discontinued early in the season because few flies were being caught after the manure had been disposed of and other breeding places eliminated. These traps were moved to new locations. In the residential part of the city near the college flies were not nearly so numerous as in 1934 when without fly control and despite a more unfavorable season for breeding, they were a general nuisance. The reports and visits of the inspector stimulated unusual efforts on the part of the barn superintendents towards eliminating breeding places. The inspector was also able to point out places where flies were breeding that otherwise would have been overlooked.—8-26-36.

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EFFECT ON CHICKENS OF ARSENIC IN GRASSHOPPER BAIT

LITTLE DANGER IN EATING ARSENIC-FED CHICKENS

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During the 1934 grasshopper campaign in Wisconsin, more than 10,000 tons of poison grasshopper bait were used in the northern counties. Incidentally, a number of deer were found dead in the woods and around small ponds, the cause of their death being unknown. Also, an endemic disease appeared among the prairie chickens which so greatly reduced the number over large areas in the grasshopper territory that only a few individuals could be found when the hunting season began. This resulted in considerable comment by farmers and sportsmen who felt that the birds had been poisoned by grasshopper bait.

The most unfortunate development was a case of arsenical poisoning which occurred in one of the counties in which considerable poison bait was spread. It resulted in the death of two persons and the serious illness of five others. On October 6, 1934, a farmer died from an unknown cause which was later decided as arsenic poisoning, although not until after burial and without an autopsy having been made; his wife died from the same cause on October 8. Two hired hands also became seriously ill, and the cause was finally diagnosed as arsenical poisoning.

Following these events, a related family carried away certain foods including chickens and eggs. Toward the end of October, various members of this family became ill, and in this case the trouble was definitely diagnosed as arsenical poisoning. November 7, a wedding dinner was held at the second home at which 10 chickens from the first farm were served. The livers were served the evening before the wedding, and many

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station as a contribution from the departments of Economic Entomology and Poultry Husbandry.

of the guests became violently ill. The doctor who attended some of the sick persons diagnosed the illness as arsenic poisoning, but it was not fully established that the illness was due to that cause.

Samples of water from both farms, a chicken and two eggs said to have come from the original farm, were sent to the state toxicologist for examination. He reported negative results, except for the chicken and one of the two eggs. In 50 grams of chicken liver, .02 mg. of arsenic were found, and one egg contained .3 milligrams. This information quickly spread through the neighborhood, and considerable alarm was expressed over the danger of eating chickens and eggs from farms in the areas where poison grasshopper bait had been used.

Because of a feeling among the people in this neighborhood that these cases had resulted from chickens feeding on poison grasshopper bait, the matter was referred to the state entomologist, E. L. Chambers, in charge of the grasshopper control program, and he detailed assistant state entomologists N. F. Thompson and A. L. Piller to make a complete investigation. Their unpublished report, from which the above information was taken, showed that the cases of poisoning were probably due to arsenic accidentally introduced into food at the home of the family in which the two deaths occurred.

However, because several of the individuals who had been poisoned were permanently disabled, strong feeling continued in the county against the grasshopper control program, and to avoid opposition against future grasshopper control programs, as well as to prevent unfavorable comments against the use of poultry products from this community, it was decided that some preliminary investigations should be undertaken.

F. E. Whitehead[1] had already shown that chickens did not eat enough food when fed only on poisoned grasshoppers or poison bran in pens, to obtain a lethal dose, although the poison bran had been spread at as high a rate as 100 pounds to the acre.

The experiments here described were then undertaken to determine whether chickens would feed upon the poison bait formula used in Wisconsin, and also to determine what danger might exist in eating poultry products from Wisconsin farms where high concentrations of grasshopper bait might be fed upon by chickens.

The experimental equipment was set up as follows: A small building on the university farm with a window in each side was made available, and 10 two-apartment wire cages were used so that in each test two birds might be fed on the same mixture. All feeding tests were made in these cages. Individual water cups were provided for each chicken, and a separate feeding pan was used for each bird. No other food except the poisoned materials was available to the birds. In the case of the checks, normal egg mash was given. A total of 24 chickens were used, and the conditions of these tests were much more severe than could ever be maintained under field conditions.

Feeding experiments.—Three general types of experiments were arranged.

[1] Whitehead, F. E. 1934. The effect of arsenic as used in poisoned grasshoppers upon birds. Oklahoma Agricultural Experiment Station Bulletin #218. June.

(1) *To determine to what extent chickens would eat poison bait made of sawdust, whey and arsenic.*

The bait was made according to the Wisconsin formula, using 100 grams of sawdust, 1 ounce of whey and 4 grams of arsenic trioxide. As a preliminary test, only four chickens were used, but they merely picked at the food, refused to eat very much of it, and became so greatly reduced in weight after two weeks that it was quite evident if a change was not made they would die of starvation. The food was then changed to a normal ration of egg mash, and the chickens quickly became apparently normal and regained their lost weight.

In another experiment four chickens were placed in cages with the floor covered with a bedding made with 100 grams of sawdust, 1 ounce of whey and 4 grams of arsenic trioxide. New bedding was added from time to time until a total of 8 grams of arsenic trioxide had been mixed in the bedding in each cage. Kernels of corn were daily mixed in the bedding, and the chickens picked it out, without showing any signs of distress, although slight signs of arsenic appeared in the droppings. All the chickens in these cages continued to gain weight throughout the feeding period.

Check tests were also run with sawdust and whey in which the chickens acted in the same way that they did with the poisoned sawdust and whey. Each time that the old material was stirred or new material added, the chickens came to the trough, but, after picking about for a short time, made no attempt to feed.

CONCLUSIONS.—Under cage conditions, chickens did not feed on poisoned grasshopper bait made according to the Wisconsin formula, and in the process of picking corn out of poisoned sawdust, did not pick up enough of the scattered bait in the process of feeding to produce any serious cases of poisoning.

(2) *To determine to what extent chickens would feed on grasshopper bait made of a mixture of sawdust, bran, arsenic trioxide and whey.*

When these mixtures were fed to chickens they started feeding, but quickly showed a dislike for the food, except that in feeding they attempted to pick out the flakes of bran, without the sawdust. The feeding was slow, and the chickens quickly lost weight. No serious condition of poisoning appeared, and none died. Each bird quickly gained weight when put on normal food.

When the food materials contained 25, 50 and 75 per cent bran, about the same conditions developed, although slightly more of the 75 per cent bran mixture was eaten. Most likely the presence of arsenic had some effect on feeding. In each case egg-laying stopped within a day or two after the feeding had begun.

CONCLUSIONS.—There is little or no danger of poisoning chickens when they have access to poison bait containing a mixture of bran, sawdust and whey, used as a carrying agent for arsenic trioxide.

(3) *To determine to what extent poison grasshopper bait is toxic to chickens when the bait is made with straight bran and whey as a carrying agent for arsenic trioxide.*

In these experiments, the first test was made with six chickens given a

ration of 100 grams of bran mash and 4 grams of arsenic trioxide. Others were put on 100 grams of egg mash containing 1, 2 and 3 grams of arsenic trioxide.

Twenty-four chickens were used in the whole experiment, two of which were checks. Only three chickens died during the experiments. Two of these died from poison and the third died from an unknown cause which we know was not due to arsenic since the chicken died before feeding. Of the two birds that died from poison, one ate at the first feeding 75 grams of poison bran from a portion of 100 grams containing 4 grams of arsenic trioxide. This chicken ate the 75 grams almost without stopping and was dead the following day. The feed remaining amounted to 25 grams and when analyzed for arsenic was found to contain slightly more than 1 gram, indicating that approximately 3 grams of arsenic had been eaten. The second chicken ate only 15 grams of the 104 gram portion, and 2.91 grams of arsenic were found in the remaining portion, indicating that this chicken had eaten approximately 1 gram of arsenic.

Other chickens given the same food in like proportions remained alive, although the feces showed strong signs of arsenic. A chicken of the size used in these experiments, varying in weight from 1290 to 1550 grams, will eat normally 100 grams of feed in a single day, but with arsenic, the feeding is drawn out for three or four days. A number of these birds ate food containing 2 grams of arsenic trioxide in three days, without death resulting. All gradually quit eating, and since there was no reason for letting them starve, they were given normal food until they regained weight, and appeared normal. When only 1 gram of arsenic trioxide was given in 100 grams of food, the chickens ate more slowly, but consumed all the food; one chicken lost weight—from 1380 to 830 grams, in 17 days. All chickens fed arsenic stopped laying eggs within a day or two, but when the arsenic trioxide was dropped to 250 milligrams per 100 grams of feed, egg laying was renewed. Some individuals even gained weight with 500 milligrams of arsenic trioxide per 100 grams of feed.

CONCLUSIONS.—Reasonable care in keeping chickens away from poisoned grasshopper bait made with arsenic trioxide, will prevent losses by poisoning. These feeding trials, here reported, also indicate clearly that chickens will not eat much poisoned bait unless all other feed is taken away from them. Chickens given their normal ration under farm conditions are not likely to eat more than a very little poisoned bait—certainly not enough to injure them.

Under cage conditions, if a chicken is allowed to feed unrestrained on poison bran, sufficient arsenic may be eaten to cause death, but if the food is taken slowly, few, if any, chickens will die, and all quickly recover with normal food.

Danger in eating arsenic-fed chickens and their eggs.—There is no danger from using the normally edible parts of any chicken fed large amounts of arsenic trioxide over a period of three months. All the edible parts of fourteen chickens were analyzed for the presence of arsenic. Data on two of these are not included because of impurities in the acids used.

Table 1.—Arsenic determinations for two control chickens and four arsenic-fed chickens.

Chicken No.	Weighing Date	Live Weight	Leg Meat	Leg Bones	Breast Meat	Breast Bone	Gizzard	Heart & Liver	Wing Meat & Bones	Blood	Bait
9992*	7/20	1025 gms.	110 gms.	42 gms.	75 gms.	19 gms.	28 gms.	31 gms.	47 gms.	25 cc.	
Arsenic			.112 mg.	.185 mg.	.06 mg.	.054 mg.	.132 mg.	.342 mg.	.333 mg.	.026 mg.	
9991	7/20	1210 gms.	138 gms.	50 gms.	125 gms.	23 gms.	37 gms.	22 gms.	55 gms.	25 cc.	
Arsenic			.185 mg.	.009 mg.	.21 mg.		.232 mg.	.232 mg.	.152 mg.	.024 mg.	
9998, Check	7/16	2090 gms.	175 gms.	62 gms.	167 gms.	37 gms.	45 gms.	42 gms.	77 gms.	25 cc.	
Arsenic			.022 mg.	.008 mg.	.064 mg.	.053 mg.	.042 mg.	trace	trace	trace	
9997, Check	7/16	2260 gms.	237 gms.	80 gms.	215 gms.	52 gms.	42 gms.	52 gms.	100 gms.	25 cc.	
Arsenic			.144 mg.	.01 mg.	.168 mg.	.09 mg.	.042 mg.	.012 mg.	trace	trace	
9989	7/9	980 gms.	135 gms.	43 gms.	90 gms.	30 gms.	26 gms.	22 gms.	46 gms.	25 cc.	Gall bladder 3 grams; Abdominal fat 18 gms.
Arsenic			.023 mg.	.22 mg.	.12 mg.	.1 mg.	.112 mg.	none	.065 mg.	.046 mg.	Trace
9990	7/9	1380 gms.	156 gms.	51 gms.	158 gms.	50 gms.	38 gms.	36 gms.	61 gs.	25 cc.	Abdominal fat 42 grams
Arsenic			.45 mg.	.46 mg.	.208 mg.	.116 mg.	.208 mg.	.23 mg.	.25 mg.	.088 mg.	Trace

* 9991, 9992—From June 10 to 20, food contained 1 gram of arsenic trioxide per 100 grams of mash. Changed June 20 to 250 mgs. per 100 grams of mash and continued to date of killing, July 20.

† 9997, 9998—Fed egg mash only; no arsenic.

‡ 9989, 9990—June 10 to 20, fed 1 gram of arsenic trioxide per 100 grams of mash. Changed June 20 to 250 mgs. per 100 grams of mash and continued to date of killing, July 9.

In tables 1 and 2 the arsenic content of the edible parts of two control and 10 arsenic-fed chickens is given. In the analyses shown in table 1, the entire portion of meat or bones was taken. In the analyses shown in table 2, only 20-gram samples were taken and the total weight of legs,

Table 2.—Arsenic taken from the main edible parts of arsenic-fed chickens.*

Chicken No.	Original Weight	Weight When Killed August 6	Leg Meat	Breast Meat	Gizzard	Heart & Liver
9978†	1460 gms.	1095 gms.	155 gms.	140 gms.	37 gms.	27 ms.
Arsenic			.16 mg.	.056 mg.	.076 mg.	.012 mg.
9994†	1480 gms.	1420 gms.	222 gms.	195 gms.	26 gms.	34 gms.
Arsenic			.33 mg.	.032 mg.	.052 mg.	.04 mg.
9985‡	1290 gms.	980 gms.	172 gms.	137 gms.	27 gms.	20 gms.
Arsenic			.144 mg.	.338 mg.	.32 mg.	trace
9986‡§	1380 gms.	1185 gms.	197 gms.	155 gms.	27 gms.	22 gms.
Arsenic			.96 mg.	.69 mg.	.28 mg.	.152 mg.
9987¶	1550 gms.	1360 gms.	210 gms.	209 gms.	33 gms.	31 gms.
Arsenic			.2 mg.	.28 mg.	.28 mg.	.248 mg.
9988¶	1330 gms.	1305 gms.	179 gms.	149 gms.	33 gms.	36 gms.
Arsenic			.072 mg.	trace	.116 mg.	.12 mg.

* All determinations made on 20-gram samples of leg and breast meat, and the remainder eaten.
† 9978, 9994—July 1 to 10, fed 250 mgs. of arsenic trioxide per 100 grams of mash. Changed July 10 to 500 mgs. per 100 grams of mash and continued to date of killing, August 6.
‡ 9985, 9986—June 10 to 27, fed 1 gram of arsenic trioxide per 100 grams of mash. Changed June 27 250 mgs. per 100 grams of mash and continued to date of killing, August 6.
¶ 9987, 9988—June 25 to August 6, fed 200 mgs. of arsenic trioxide per 100 grams of mash.
§ There may have been an error in this case, because the amounts of arsenic seem a bit high.

breasts and wings includes both meat and bones. The remaining portions of these chickens were cooked and eaten with a normal meal.

The largest total shown here is 2.08 milligrams in 401 grams of edible food, and since 130 milligrams is given as the approximate lethal dose for

Table 3.—Amount of arsenic in eggs from arsenic-fed chickens.

First Eight			Last Six	
Grams Weight	Mgs. of Arsenic Trioxide	Grams Weight	Shell, Grams Weight	Mgs. of Arsenic Trioxide
41	.024	39.5	4	.024
46.5	.024	46	5	.052
45.5	.022	42	4.5	.012
40	.016	42	4.5	.036
33.5	trace	46	4.5	.036
39.5	.0025	55	5	.036
40	.026			
42	.012			

human beings, one would have to eat approximately 60 chickens at one meal to get enough arsenic for a minimum lethal dose. In the final stage of the experiment, the last six of the experimental chickens fed on varying amounts of arsenic from April 29 to August 6, were cooked and eaten by a number of persons, without any noticeable effect.

Arsenic content of eggs from arsenic-fed chickens.—During the period of the experimental feeding, all eggs were saved and held in refrigeration until the last chicken was killed.

From the first eggs laid after the chickens were placed on food containing arsenic, eight were selected at random for analysis. Six additional eggs laid late in July by chickens that were continued on arsenic food from June 10 to August 6 were also analyzed. The results are shown in table 3.

After analysis of the last six eggs, it became evident that there was not enough arsenic in any egg to cause alarm, and so all the eggs were used for food. One person ate 24 eggs from arsenic-fed chickens in four days without any signs of disturbance. A trace of arsenic can be found in almost every egg, and although indicated traces were found in separately analyzed egg shells, no significance was attributed to that fact. Neither is any significance given to the higher arsenic content of four of the last six eggs analyzed.

Droppings.—Chicken droppings were collected at various times for study and analysis. It was noted that within a day or two after arsenic was fed to chickens, the droppings became green and watery, mixed with the white droppings of the urea. Since no effort was made to collect the entire excreta of any chicken, such analyses as were made have limited significance.

Solid mixed droppings collected May 9 from a check bird gave just a trace.

White droppings without any green never gave more than .022 mgs., while green droppings showed as high as 5 mgs. in 16 grams of excreta.

On May 14, identical samples of green and white droppings were taken from bird 9988E. Twenty-two grams of dark green excreta contained 2.75 mgs. of arsenic; 20 grams of white droppings contained onlv a trace.—7-6-36.

NOTES ON CLOTHES MOTH BREEDING

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Breeding of clothes moth, *Tineola biselliella* Hum., has until recently been a procedure of considerable difficulty. During the last few years much work has been done in developing breeding methods so that the necessary insect material for testing clothes moth remedies may be always available. During the course of this work a number of interesting phenomena have been discovered. Some of these are here indicated.

Clean woolens.—We have been unable to breed clothes moths on thoroughly clean woolens. A large variety of clothes have been tested with uniformly negative results. This is in accordance with Titschack (*3*), who likewise found that clean untreated wool was not nutritionally sufficient for clothes moths. Eggs laid on such woolens hatch normally but the little larvae feed slightly or not at all and death from apparent starvation follows in about two weeks. Imperfectly cleaned woolens or woolens exposed to normal quantities of house dust over a period of 10 days or more may not appear dirty, but newly hatched larvae will feed on them to a variable extent depending on the quality and quantity of

the dust involved. However, this does not present a satisfactory breeding method, as usually the larvae are not able to complete their growth in spite of considerable feeding. Such larvae tend to be pale white and they do not have the characteristic greasy appearance of the normal larvae. If adults are allowed to die on otherwise clean woolens, it will be found that the larvae feed extensively on the woolen around the dead moths, which are finally consumed. Such larvae may complete their development, especially if dead adults are numerous. Larvae removed from suitable diets to clean woolens may feed extensively although the smaller ones produce undersized adults or may not complete their development. Certain, but not all, food stains stimulate larval growth but many do not permit pupation. Certain animal pelts that were tested, notably rabbit and fox, breed moths continuously without supplemental treatment.

Breeding supplements.—Colman (*1*) and Griswold (*2*) suggested the use of yeast and fish meal, respectively, in connection with woolen goods. The woolen goods used is a broadcloth with a heavy nap on both sides. The yeast is dry brewer's yeast and the fish meal is of high white quality. The latter may be used alone as a breeding medium. Either of these materials dusted lightly but thoroughly onto woolen goods of suitable quality, furnishes, in combination with the goods, a complete diet for the larvae. At 80° F, eggs laid on it hatch in the course of three or four days, and within 18 days the little webs can be seen developing in the nap. The larvae at this point are very small but their color, as in later stages on these diets, is greasy yellowish. The fatty or greasy appearance is characteristic for all healthy clothes moth larvae although the color may change somewhat with the character of the food. The first generation of adults may develop in about 55 to 60 days at 80° F. Under proper conditions breeding is entirely continuous and five or six generations a year have been repeatedly obtained.

Yeast autoclaved at 248° F for one to five hours was found even better than the unautoclaved material. Eggs laid on woolen goods dusted with such autoclaved yeast, in the same manner as previously described for normal yeast, produce, at 80° F, first-generation adults in 42 to 50 days, a reduction in our tests of about 10 days in the time required to produce them when using unautoclaved yeast. A further advantage of autoclaved yeast lies in the fact that breeding jars do not need to be washed out at the end of each generation. All that is required are additional woolen goods and autoclaved yeast. When unautoclaved yeast or fish meal is used the jar must usually be thoroughly cleaned when the first-generation adults have emerged, otherwise soon thereafter the mortality rate rises abruptly even though an abundance of suitable food is available. The old piece of yeasted goods is largely unsuitable although it may be fed on to some extent, and adding more yeasted goods is of no avail although it also may be fed on to some degree. A second generation of larvae may start but few if any survive the very rapid increase in mortality that soon develops and quite frequently late first-generation larvae that may be present also fail to pupate and die. This stagnation is associated with a collection of frass and debris on the bottom of the breeding jars together with a peculiar rancid odor. New cultures must ordinarily

be started with fertile adults and fresh food materials in clean jars. Autoclaved yeast does not act in this way. In a number of tests, three generations of adults have appeared in numbers and normal fourth generations are starting in 175 days. Much frass and debris also accumulated in these jars but without serious detriment to the moths. It is not our purpose to state that the use of autoclaved yeast obviates the necessity for cleaning the breeding jars from time to time. It is merely intended to say that at least two or three generations can be continuously bred in the same jars by the simple additions of woolens and autoclaved yeast. No explanation is offered at this time. Fish meal autoclaved and used in the same manner did not prevent a subsequent high rate of mortality after the first generation of adults emerged, even though numerous newly hatched larvae appeared and plenty of food was available.

Egg production.—It has been found possible to procure suitable quantities of clothes moth eggs with facility by reason of the fact that adults will lay eggs freely through a 14-mesh wire screen onto a piece of woolen goods. A cage 8 inches tall by 5 inches in diameter, consisting of an ordinary fine-mesh wire cylinder with metal collars at both ends, is used. The top is covered by a piece of cheesecloth held in place by rubber bands, and a hole in the cheesecloth, which is covered by a removable screen top, permits adults to be introduced. A 14-mesh wire screen is securely fastened over the other or bottom end and a piece of woolen goods is secured on the outside of this. Fifteen normal recently emerged adults will lay 50 to 75 eggs in a 48-hour period in a warm (80° F) dark place if undisturbed. Additional adults should be added from time to time and the dead removed. In practice, no attention is paid to sex. The 15 adults are selected at random and probably about half are males. At the end of the 48-hour period the flannel is shaken vigorously in a large paper funnel and the eggs, which are loosely deposited in the nap, fall readily through the hole in the funnel into a container. Eggs obtained in this manner give a very satisfactory hatch and have been used extensively. They hatch three or four days after oviposition so that use in a day or two is always indicated. A camel's-hair brush is suitable for handling them.

Summary.—Clean woolen goods are nutritionally deficient for newly hatched clothes moths. Ordinary house dust and food stains have a stimulating but variable effect on clothes moths. Fish meal and yeast have been found by other workers to be valuable nutritional supplements for clothes moths. Autoclaved yeast is superior to unautoclaved yeast as a clothes moth supplement. A method for procuring clothes moth eggs in quantity is described.—8-31-36.

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INSECT FAUNA OF CURED TOBACCO IN STORAGE IN THE UNITED STATES

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Scope and plan of study.—After tobacco is cured, it is often held in storage from two to four years by manufacturers and dealers. During this period it undergoes processes of fermentation that give it the desired flavor and aroma. As a result of the necessity for "aging," large stocks of tobaccos are constantly in storage. For example, there is held in storage in the United States at all seasons of the year around 80 million pounds of imported Turkish tobacco, 750 million pounds of domestic flue-cured tobacco, 850 million pounds of Burley tobacco, 220 million pounds of fire-cured tobacco, 180 million pounds of cigar-filler tobacco, 200 million pounds of cigar-binder tobacco, and 100 million pounds of miscellaneous types, or a total of 2380 million pounds of tobacco. These stocks, in varying degrees, offer suitable environments for the growth of certain insects and other arthropods, some species of which are destructive pests of the tobacco and in consequence are undesirable from an economic standpoint; while other species are parasites or predators on the harmful species and are therefore beneficial.

Inasmuch as cured tobacco, because of its nicotine content, would not appear to be a very favorable habitat for insects, it is thought to be of interest to record the insects and related species that find a suitable environment within this commodity. Based on the relationship of the various species to each other and to the environment, the fauna of cured tobacco may be divided into two groups.

The first group includes the species that have a definite relationship to the tobacco in that they feed on it or act as parasites and predators on the species that do. This group may be further subdivided into three parts: (1) *Ephestia elutella* Hbn., the tobacco moth, and its associated species, (2) *Lasioderma serricorne* Fab., the cigarette beetle, and its associated species, and (3) other species that feed occasionally on tobacco.

Both the tobacco moth and the cigarette beetle are cosmopolitan in distribution and each of them exists on such a wide variety of food products that were tobacco completely eliminated they would still have to be regarded as important pests of stored products. The tobacco moth is notably a pest of chocolate products, and the cigarette beetle, although of greatest importance as a pest of tobacco and tobacco products, is also a destructive pest of furniture upholstering, and many kinds of spices and flavoring materials in the dry state.

The second group includes miscellaneous insects, many of which bear no definite relationship to the environment but which are chance inhabitants and are only at times found in tobacco. The purpose of this

[1] The authors are indebted for assistance in the identification of the species listed in this paper to specialists of the Division of Identification and Classification of Insects, particularly to C. Heinrich, W. S. Fisher, A. B. Gahan, and H. E. Ewing.

paper is to list and give brief notes on the insect fauna of both of the groups found in cured tobacco.

Habitat, the tobacco warehouse.—Warehouses in which tobacco is stored are usually of two types; (1) the open storage, and (2) the closed storage.

The open-storage warehouse is usually made of sheet-iron walls, with concrete or dirt floors, and tar and gravel roofs. It is seldom more than one story high. On the sides large ventilators run the entire length of the building. In some cases it is possible to close them partially, but generally they remain open permanently in order to insure the greatest amount of ventilation in the building.

The closed storage is ordinarily constructed of brick or concrete. It may be one or more stories high. These warehouses are provided with ventilators in the walls and roofs but they provide much less circulation than those in the open storage.

Cured tobaccos are placed in several kinds of packages for storing, such as hogsheads, cases and bales. Most of the flue-cured cigarette-type tobaccos are packed in wooden hogsheads, each about 54 inches tall and 48 inches in diameter. The Burley, dark fire-cured, and sun-cured types are packed in hogsheads also, which may measure in some instances 60 inches in height and 48 inches in diameter. The hogsheads may contain 1000 pounds each of the flue-cured and Burley types to 1600 pounds of the dark fire-cured types. Cigar tobaccos are packed in cases, bales or barrels of varying sizes and dimensions. Most of the cigar filler is packed in wooden cases each about 42 by 30 by 30 inches and containing approximately 150 pounds of tobacco. Sumatra wrapper bales are each about 34 by 17 by 32 inches and weigh approximately 150 pounds per bale. Bales of cigar-filler tobacco measure about 32 by 23 by 20 inches and contain 137 to 150 pounds each. Some types of cigar-filler tobaccos are packed in wooden barrels 30 inches tall and 36 inches in diameter and each contains 137 to 150 pounds of tobacco.

The Turkish-type tobaccos imported from the near east (Greece and Turkey) are packed in bales 30 by 20 by 14.5 inches, each weighing 112 to 140 pounds. In some instances these tobaccos are packed in smaller bales which vary in size but usually measure 30 by 20 by 6 inches and contain approximately 40 pounds each.

Species having relation to tobacco. *Ephestia elutella* HBN. AND ASSOCIATED SPECIES.—*Ephestia elutella* Hbn., the tobacco moth, is distributed throughout the greater part of the world, and is found infesting many different kinds of stored products (*1*), among which the most important are perhaps tobacco, cacao beans and chocolate. Prior to 1929 (*7*), when its damage to tobacco was observed in England, cacao and chocolate had been considered its chief foods, although as early as 1915 it had been reported as a tobacco pest in Russia (*5*). In 1930 (*1*) the moth was noted heavily infesting stored tobacco in the flue-cured tobacco belt of the United States. Since all reports of *E. elutella* infesting tobacco are comparatively recent, it appears that the species has only lately begun to acquire a taste or preference for tobacco.

Studies of the feeding habits of the species show that it has a prefer-

ence for the higher grades of flue-cured domestic and imported tobaccos. It has never been found in tobacco of the cigar types, nor in Burley or sun-cured types. Experiments in rearing *E. elutella* on tobacco show that even on high-grade flue-cured tobacco only a small percentage of the newly hatched larvae become established. However, because of the fact that the species is such a prolific producer of eggs, which under natural conditions have few effective enemies, and because it has so few enemies in its other stages, it has become established as a rather serious pest of the cigarette tobaccos.

A very important requirement for the successful rearing of *E. elutella* is that the tobacco have a moisture content of 11 to 15 per cent. Relative humidity of 65 to 75 per cent in the air produces the optimum moisture content of the tobacco. Tobacco dries out rapidly when stored at low humidities, becoming hard and brittle. In this condition it is not relished by the larvae, which are able to live through short periods of a few weeks in the growing season without food. Under the conditions of tobacco storage it is seldom that the moisture in the tobacco falls below 10 per cent because the tightness and compactness of the tobacco bales and hogsheads tend to conserve the moisture. An added factor in the maintenance of the high moisture content of the tobacco in storage in the eastern section of the United States is the high relative humidity that prevails from May to October, the growing season of the insect.

Microbracon hebetor (Say) parasitizes the larvae of many species of moths, especially those of the genera *Ephestia* and *Plodia*. The insect parasitizes the larvae of *E. elutella* in tobacco warehouses, but never becomes abundant enough to be regarded as a satisfactory control. Adults are seldom abundant except at the end of the growing season. In the spring it is not often found, a fact indicating that it survives the winter in tobacco warehouses in very small numbers. Since the warehouses are well ventilated in winter, as well as during other seasons of the year, the hibernating adult is exposed to sudden changes in the weather. However, whether it is the effect of weather factors, or a number of combined factors in which the tobacco itself must be considered, that prohibits the growth of large populations in warehouses and hinders its effectiveness as a natural control is not definitely known.

Mesostenus gracilis Cress. is an occasional parasite of the larvae of *E. elutella*. Its occurrence is so rare that it is considered negligible in the control of its host.

Seius sp. is commonly found living as a predator on adults of *E. elutella* in tobacco warehouses. The mites are usually found attached to the vertex of the head and to the thorax near the bases of the wings, but may be found on any section of the body.

Theridion tepidariorum Koch. is sometimes found in tobacco warehouses that are infested with *E. elutella*. This spider snares the adult moth in webs built inside the warehouse, usually near the hogsheads or bales of tobacco. As the adult moth flies rather freely and usually seeks a hogshead or bale when ovipositing, it often becomes entangled in the web and is later eaten by the spider. Usually only the older moths are entangled well enough to prevent escape, and observations have shown

that most of the females captured had laid the greater part of their eggs. Occasionally, the spider takes up its abode in the receptacle of the suction light traps operated in warehouses and feeds on the moths that are captured.

An unidentified predacious mite (Acarina, Parasitidae) related to the genus *Laelaps* feeds on the eggs of *E. elutella*. This mite has been found in the receptacle on the suction light traps operated in warehouses, feeding on the eggs of the moth. The writers have not collected this species from cured tobacco.

Lasioderma serricorne FAB. AND ASSOCIATED SPECIES.—*Lasioderma serricorne* Fab., the cigarette beetle, an insect of world-wide distribution and a feeder on many kinds of dried stored products, is the most destructive insect found in cured tobaccos. The larval stage feeds on many types of tobaccos but prefers the high-grade cigarette types. The beetle is a prolific breeder and increases rapidly in tobacco warehouses during the warm months. Small populations, which may at the beginning of the growing season seem negligible, often increase to damaging proportions by early fall. The adult beetles appear to have a natural tendency to disperse, especially in September and October, when they are often attracted to lights on the streets and in homes in the vicinity of tobacco warehouses.

Aplastomorpha calandrae (How.) is the only insect parasite of the larval stage of the cigarette beetle that has been found in tobacco warehouses. It cannot be regarded as a worthwhile factor in the control of beetle infestations. When the host is present in large numbers, however, the parasite becomes very abundant. The adult doubtless finds it difficult to make its way into the tightly packed tobacco through the feeding tunnels of the host larvae. In severe infestations of the cigarette beetle, the feeding tunnels of larvae often cross, in which case the exit hole of an early maturing individual may afford the female parasite easy entrance. This condition apparently accounts for the large populations of the parasite that sometimes develop in tobaccos heavily infested by the host and for the lack of the parasite to build up its numbers noticeably in infestations that have not become heavy. Both sexes of *A. calandrae* are winged, and are strong fliers.

Kearns (*4*) reported that in Illinois *Cephalonomia gallicola* Ashm. was a parasite of *L. serricorne* in cultures grown artificially. This parasite has not been found in tobacco warehouses, although observations have been made over a period of four years in connection with extensive trapping experiments.

Pediculoides ventricosus Newp. is sometimes found in cured tobacco preying on larvae of *L. serricorne*, but has not been observed attacking the larvae of *E. elutella* under natural conditions.

Tenebroides mauritanicus (L.) is sometimes found in small numbers in tobacco warehouses preying on the immature stages of tobacco pests, especially the larvae of *L. serricorne*. It is classed as a pest of grain products and bears the common name *cadelle*. This insect has not been observed feeding on tobacco.

Thaneroclerus girodi Chev. has been collected only in Florida from

stored tobacco. The beetle and its larvae are predacious on all stages of the cigarette beetle.

OTHER SPECIES FEEDING OCCASIONALLY ON TOBACCO.—*Catorama tabaci* Guerin has been reported to be a feeder on tobacco (*6*). It has never been collected by the writers in the bright tobacco belt.

The larva of *Aglossa* sp. (presumably *cuprealis* Hbn.) is sometimes found feeding on tobacco that is molded or decayed.

Miscellaneous species.—A number of species of other insects have been found by the writers in cured tobacco, but none of them was observed feeding on the tobacco. This list includes, in the order of their abundance, the following: *Tribolium confusum* Duv., *Henoticus serratus* Gyll., *Cathartus* (*Ahasverus*) *advena* Waltl., *Typhaea stercorea* L., *Anthrenus verbasci* Oliv., *Lepisma saccharina* L., *Ptinus brunneus* Duft., *Tribolium ferrugineum* Fab., *Attagenus piceus* Oliv., and *Trogoderma* sp. Some of these insects act as scavengers, while others probably use the tobacco as a temporary shelter. The writers have not observed any of the above species feeding on tobacco.

Several species of insects have been found in tobacco by other writers. Runner (*6*) reported that *Silvanus surinamensis* L. had been found feeding to a slight extent on cured tobacco. He also recorded that *Mezium americanum* Laporte had been found frequenting tobacco. Jones (*3*) stated that *Dinoderus brevis* Horn was found frequenting cured tobacco in the Philippines. Howard (*2*) stated that *Sitodrepa panicea* L., *Calandra oryza* L. and *Dermestes vulpinus* Fab. were capable of injuring cured tobacco.

Summary.—Because of the necessity for "aging" cured tobaccos from two to four years, large stocks, which afford a suitable habitat for insects and other arthropods, are constantly in storage in the United States. For example, the amount of tobacco in storage at all times is approximately two and one-half billion pounds.

For purpose of discussion, the fauna of cured tobacco is divided into two groups, the first of which includes all of the species that feed on tobacco together with their parasites and predators, and the second the miscellaneous species that temporarily inhabit tobacco.

The pests, with their parasites and predators, that are found in tobacco include *Ephestia elutella* Hbn., *Microbracon hebetor* (Say), *Mesostenus gracilis* Cress., *Seius* sp., *Theridion tepidariorum* Koch, a species of mite related to the genus *Laelaps*, *Lasioderma serricorne* Fab., *Aplastomorpha calandrae* (How.), *Pediculoides ventricosus* Newp., *Tenebroides mauritanicus* (L.), *Thaneroclerus girodi* Chev., *Catorama tabaci* Guerin and *Aglossa* sp. (presumably *cuprealis* Hbn.). It is reported in the literature that *Cephalonomia gallicola* Ashm. parasitizes the larva of *L. serricorne*, but the parasite has not been observed attacking the larva of this host in tobacco.

In the group of species that are not dependent on tobacco for existence, other writers have reported *Silvanus surinamensis* L., which is said to feed to a slight extent on tobacco, *Mezium americanum* Laporte and *Dinoderus brevis* Horn. *Sitodrepa panicea* L., *Calandra oryza* L. and *Dermestes vulpinus* Fab. are reported to be capable of injuring tobacco.

The miscellaneous species found by the writers include, in the order of their abundance, *Tribolium confusum* Duv., *Henoticus serratus* Gyll., *Cathartus (Ahasverus) advena* Waltl., *Typhaea stercorea* L., *Anthrenus verbasci* Oliv., *Lepisma saccharina* L., *Ptinus brunneus* Duft., *Tribolium ferrugineum* Fab., *Attagenus piceus* (Oliv.) and *Trogoderma* sp.—8-22-36.

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Scientific Notes

The Fluorine Compounds as Insecticides. A Monograph with Annotated Bibliography.—During the last few years there has been a marked demand for new and better insecticides. This demand has been largely the result of two factors, first the need for better control of a great variety of insects which are on the increase in their economic destructiveness, and second the recognition of the health hazards of the residues from certain insecticidal sprays and dusts if they are left on food products intended for human and animal consumption.

One of the principal classes of inorganic materials investigated as substitutes for the arsenicals were the compounds of fluorine. These compounds, especially sodium fluoride, have been recognized for years for their insecticidal properties chiefly as the active ingredient of roach powders, ant poisons, dusts for chicken and cattle lice and such uses.

Prior to 1924, however, very little experimental work had been done with these compounds in tests against insects affecting field crops. Marcovitch was one of the first to recognize the possible value of these compounds for this purpose and in 1925 published the results of experimental tests of several fluorides and fluosilicates against several kinds of chewing insects. About the same time several other investigators also reported very favorable results with these compounds against chewing insects. During the next 10 years all the fluorine compounds which were considered practical from their physical and chemical properties were tested against practically all chewing insects affecting field crops.

When experimental work was started with these compounds on vegetables and fruits and other materials intended for human and animal consumption, the danger of chronic toxicity due to ingestion of very small amounts of fluorine over long periods of time was not recognized. Within the last few years, however, it has been demonstrated by Smith and others that areas in which mottled enamel of teeth is endemic coincides with areas in which fluorine is present in the water supply. Because of these facts and much other evidence supplied by toxicologists the Food and Drug Administration of the U. S. Department of Agriculture has announced a tolerance for the amount of fluorine which may be present as spray residue on food materials shipped in interstate commerce. Difficulties have been encountered in removing fluorine spray residue from fruits and vegetables to

meet this tolerance and this fact has prevented recommendations for their use in some cases where toxicity to the insect and freedom from plant injury have indicated their value.

For the convenience of those interested it was considered advisable at this time to present a summary of the available information on the insecticidal properties and applications of the compounds of fluorine. There was included also the information available on fluorine spray residue removal and such methods of analysis as are applicable to this type of work. References to the use of fluorine compounds in wood preservation and like applications where insect damage may be a factor were also included but purely bactericidal and germicidal uses were not. Plant damage incidental to the use of fluorine insecticides was also considered pertinent to this review and the available information along this line was included. A discussion of the physical and chemical properties of the fluorine compounds was also included.

Over 600 references to the literature from 1898 to 1934 were abstracted with these points in mind.

It is evident that several compounds of fluorine, for instance cryolite, barium fluosilicate, potassium fluosilicate, etc., are safe to use on foliage in many cases, and possess satisfactory toxicity to chewing insects such as codling moth, Mexican bean beetle, blister beetles, cucumber beetles, etc., but cannot be recommended for use without provision being made for the removal of the residue from food materials. For moth proofing, wood preservation, roach powders, chicken lice powders, poison baits and other uses where the residue removal is not a factor, many of these compounds find quite extensive use.

It is proposed to publish this monograph in the "E" series of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. This publication will be available for distribution about January 1, 1937.

R. H. CARTER, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* 9-12-36

***Coccidophilus citricola* Brèthes, A Predator Enemy of Red and Purple Scales.**—In 1934–35 the Citrus Experiment Station at Riverside, Calif., introduced into California a small beetle belonging to the family Discolomidae. Brèthes (*1*) described this beetle as *Coccidophilus citricola*. E. C. Van Dyke informed the writer that "While the monotypical genus *Coccidophilus* is placed in the family Discolomidae, this is itself but little more than a subfamily of the Colydidae. The family Discolomidae structurally diverges somewhat from the Colydidae and approaches the Coccinellidae. All members of the family Colydidae are either predacious or fungivorous, none phytophagous, and no doubt the members of this subfamily share the same habits."

The specimens of *Coccidophilus citricola* received at Riverside were collected by H. Compere in Brazil, about 30 miles from Rio de Janeiro. Previously this species had been recorded from Argentina, Chile and Paraguay, so that it probably is generally distributed throughout subtropical and temperate South America.

This beetle attacks the two worst pests of citrus, *Lepidosaphes beckii* and *Chrysomphalus aurantii*. Porter (*6*) states that near Santiago, Chile, it controlled several species of *Aspidiotus*. Salvadores (*7*), on finding that it fed on *Lepidosaphes beckii* on lemon and orange trees, advocated its artificial propagation. Blanchard (*2*) found that it occurs almost everywhere in Argentina and is one of the most active checks on *Lepidosaphes beckii*. Elgueta (*4*) states that it probably restricts the spread of red scale in Chile. Compere, however, informed the writer that apparently it had little or no economic value in reducing the abundance of its hosts. Many of the citrus trees from which the beetles were collected were injuriously infested with *Prontaspis citri*, *Lepidosaphes beckii* and *Chrysomphalus aonidum*.

On September 22, 1934, a shipment was received from Compere that included 12 live adults of *Coccidophilus*. These were sent by air express and were en route seven days. No trouble was experienced in obtaining reproduction in the insectary.

In the introduction and establishment of parasites and predators the Citrus Experiment Station is aided by the several county and cooperative insectaries.

The Orange county insectary received a stock of *Coccidophilus citricola* and propagated it in large numbers. At this insectary a method was developed by Mr. Rush Bumgardner for obtaining the hosts of this beetle in enormous numbers. This is done by growing the host scale on mature gourds or squashes. When placed on racks in a warm, dry room the squashes remain in good condition for six months or a year and permit the scales to de-

velop for several generations. The scale population may become dense enough entirely to cover the surface of the squash. This method has made possible the production and liberation of many thousands of beetles. In August 1936, Bumgardner recovered specimens of the immature stages of *Coccidophilus* from the field. Apparently this beetle is established in California.

In appearance, the adult *Coccidophilus citricola* is jet black and strongly convex. The sexes are alike in color and difficult to differentiate. Newly emerged specimens are reddish. Apparently this transitory coloration was observed in field-collected specimens by Lizar (*5*). However, he concluded that they represented a variety of the black form.

Oviposition commences within five days after emergence; the eggs are placed beneath the covering of the scale insect. They are translucent yellow and the chorion is delicate and flexible.

At 80° F the incubation period is eight or nine days, the ocelli of the embryo becoming visible two days before hatching.

The newly hatched larva has a brown, flat body, finely pubescent, and the head is black. The terminal segments of the abdomen are hairy. The first thoracic segment is light brown or gray, with two black patches. The legs are lighter in color, with black knees. The larvae cease feeding after 10 days. Then they are somewhat pear shaped, tapering toward the head and appear to be dark velvety brown. Under the microscope the epidermis is found to be covered with minute "rosettes," each consisting of five to seven spines. A few long hairs are scattered over the body.

The entire larval stage extends over a period of 13 to 20 days. At the end of this period they seek crevices in which to pupate.

The pupa is yellowish brown and very hairy. Several days after pupation each hair bears a globule of liquid at the tip. The pupal period of five days is comparatively short.

Both adult and larva when disturbed tend to adhere to the host plant with adhesive anal discs.

At a temperature between 75° and 85° F, the life cycle is 27 to 35 days.

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S. E. Flanders, *Riverside, Calif.* 8-25-36

Japanese Species of *Tetrastichus* Parasitic on Eggs of *Galerucella xanthomelaena* (Schrank).—One of the cooperative projects of the U. S. Bureau of Entomology and Plant Quarantine and the University of California is the biological control of the elm-leaf beetle in the Great Central valley of California.

During the last 30 years a number of attempts have been made to establish in the United States the European egg parasite of the elm-leaf beetle, *Tetrastichus xanthomelaenae.* Most of these introductions occurred along the Atlantic seaboard, but in 1933 two shipments were received in California and several colonies were liberated near Fresno. No recoveries of *Tetrastichus xanthomelaenae* have yet been made.

In Japan elms are attacked by a closely related beetle, *Galerucella maculicollis* Mots. A number of years ago C. P. Clausen observed that the eggs of this beetle were parasitized by an apparently undescribed species of *Tetrastichus.* As no recoveries have been made of the European *Tetrastichus,* Mr. Clausen suggested the introduction of the Japenese parasite in California. Professor H. S. Smith agreed to handle the material in California, and so arrangements were made with the Bureau's representative in Japan, R. W. Burrell, to

make the shipments. Two shipments were forwarded, one in June 1934, and one in June 1936.

In the 1934 shipment about 35 per cent of 1112 egg masses were parasitized. In the 1936 shipment the parasitism of 553 egg masses was approximately 45 per cent. Only one parasite matured in a single host egg. The sexes occurred in equal numbers.

During the rearing of these parasites in California, a few observations were made on certain biological factors that probably directly influence establishment.

At a temperature of about 70° F the life cycle is 24 days. The larva is full grown seven days after deposition of the egg. Pupation occurs six days later. The pupal period is about 10 days. At higher temperatures the life cycle may be as short as 14 days. Fiske (*1*) found this to be the case with *Tetrastichus xanthomelaenae*.

The parasite emerged from the foreign material over a period of 24 days. The emergence from a single egg mass, however, was completed within 10 days.

Dissections made on receipt of each shipment revealed the presence of full-grown larvae as well as pupae. Curiously, after the adult parasites had ceased to emerge, full-grown larvae were found in considerable numbers. Although many appeared to be in a healthy condition, none completed its development. The material was 14 days in transit at a temperature of about 38° F. This exposure apparently inhibits the development of both the host embryo and the "prepupal" stage of the parasite. In a typical egg mass from which parasites have commenced to emerge, dissection showed the presence of pupae, full-grown living and dead larvae of the parasite, and dead beetle larvae.

To survive, adults must imbibe liquids within 20 hours after emergence. The ovaries of newly emerged females contain no eggs. Eggs are not fully formed until three or four days after emergence at temperatures of about 80° F. After a female deposits a number of eggs it begins to feed on the content of host eggs, a habit first noted by Marchal (*1*). The ovaries of one female seven days old, that had fed only on honey, contained 14 fully developed eggs.

A six-day-old female was placed for 13 hours in a vial containing a mass of 15 eggs. Seven days later 12 of them had changed from yellow to lavender, an indication that the parasite had become full grown. The tips of such eggs are whitish because the darkened vitelline membrane is separated from the chorion by a clear liquid. One of the remaining three eggs which were unchanged in color contained a first stage larva. Although apparently unparasitized, embryonic development in the other eggs remained incomplete.

The progeny of unmated females developed as primary parasites of the elm-leaf beetle. No mated females were available for reproduction. Copulation apparently did not take place. A possible explanation of this is that the low temperatures during shipment (when the parasites were for the most part in the pupal state) had a castrating effect on the male.

Successful establishment probably would be facilitated by holding the parasites in confinement until sexually mature. The availability in the field of liquid food for newly emerged adults may also influence establishment. Without such food the adult probably would not survive the preoviposition period.

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S. E. Flanders, *Riverside, Calif.* 8-14-36

***Geocoris punctipes* Say Observed as Predaceous upon Eggs of *Phlegethontius* sp.**—A very interesting observation was made by the writer on June 4, 1936, while examining tobacco plants in the vicinity of Oxford, N. C. A partially collapsed hornworm egg was observed and standing nearby was a nymph of *Geocoris punctipes* Say (determined by H. G. Barber). The nymph was captured and in the next few days ate several hornworm eggs. This nymph within a few days became an adult and continued to devour hornworm eggs. Other nymphs collected were noted as being cannibalistic, as were the adults. This predator was observed to be plentiful in tobacco fields on June 22, when four individuals were observed upon one tobacco plant. Although *G. punctipes* is recorded by Chamberlin & Tenhet (U.S.D.A. Farmers' Bulletin 1352) as being predaceous upon the tobacco flea beetle, *Epitrix parvula* Fab., it is believed that this is the first record of the species attacking eggs of the tobacco hornworm.

J. U. Gilmore, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* 8-3-36

A Food for Rearing Laboratory Insects.—Rearing large numbers of insects for experimental purposes often presents special problems of proper nutrition. For two years past there has been used in the Division of Entomology and Economic Zoology of the University of Minnesota a formula which seems admirably suited to the rearing of diverse species of stored products insects and grasshoppers.

It has been used with success for rearing wax moths, *Galleria melonella* and *Achroia grisella*, the saw-toothed beetle, *Orizaephilus surinamensis*, Indian-meal moth, *Plodia interpunctella*, *Trogoderma* spp., as well as other Dermestidae and grasshoppers. Undoubtedly many other species can be reared on this food.

The formula is as follows:

I. Corn flour ..... 4 parts by weight
Whole-wheat flour ..... 2 parts by weight
Skim-milk powder ..... 2 parts by weight
Dried powdered yeast ..... 1 part by weight
Wheat middlings or bran ..... 2 parts by weight

Mix the ingredients thoroughly and stock in a tight container in order to prevent infestation by insect pests.

II. Mix well equal parts of honey and glycerine by volume. This mixture can be stored at room temperature.

Mix equal parts of I and II by weight. Let the mixture stand for about 24 hours to allow the liquid to penetrate the dry components of the food. Then place clumps of this mixture in mason jars provided with screen covers, inoculate with the desired species of insect and place in a constant temperature chamber adjusted to the optimal temperature and humidity. Temperature of 32° C. and 75 per cent relative humidity are used in our laboratories. The food remains soft for an indefinite time because honey, due to its hygroscopicity, absorbs moisture from the air and glycerine prevents molding and contributes further to the softness of the food. The proportions of I and II can be changed to suit the feeding habits of any given species. For some, the liquid may even be left out. The food is coarser and more to the liking of certain species when bran is used in place of middlings.

Stored-products insects as well as other species which live on a relatively dry food can be reared in mason jars for generations. In the case of chewing insects, such as grasshoppers, living on the leafy parts of plants, eggs are placed on the food in screen cages and a dish containing cotton or cheesecloth is filled with water and placed close to the food.

MYKOLA H. HAYDAK, *University of Minnesota*. 8-4-36

Long Survival of *Gibbium psylloides* Czemp.—An infestation of the ptinid beetle, *Gibbium psylloides* Czemp., was maintained for at least 18 years in a glass jar of wheat bran at Mississippi State College. The bottle was fitted with a ground-glass stopper and nothing was added at any time during the period. The infestation was first noticed in the agronomy department sometime before 1916 and the jar was turned over to the Zoology and Entomology department October 21, 1924. A layer of dead beetles gradually accumulated on top of the bran until it became an inch deep. The infestation died out in the fall of 1934 while the writer was absent from the office for several weeks. It is possible that the jar was placed in sunshine by a careless janitor for the beetles had appeared normally active only a few weeks before.

CLAY LYLE, *Mississippi State College, State College, Miss.* 8-28-36

A Crane Fly Larva Attacking Newly Set Strawberry Plants.—During March 1936, larvae of the crane fly *Nephrotoma ferruginea* Fab.,[1] were found to be causing severe injury to newly set strawberry plants in the vicinity of Chadbourn, N. C. These larvae were also observed destroying young tobacco seedlings in a plant bed.

Observations in an infested strawberry field disclosed that the crane fly larvae were attacking the crown of the plants and had eaten away the living tissue to a point just below the origin of the bud. All plants suffering this type of injury had died or were in a greatly weakened condition. In addition, the crane fly larvae had destroyed such portions of the leaves or petioles as were in direct contact with the soil.

Infested plants had one to three larvae feeding thereon, and as many as eight to 12 larvae were taken from a sample of soil 3 inches square and 1 inch deep, in the space between the

[1] Determined by Alan Stone.

plants. The larvae were present just underneath the soil surface. They had thoroughly pulverized the soil adjacent to the plants as well as pulverizing the soil in small depressions of the field where sediment had collected. In many parts of the field the soil surface was covered with interlacing ridges of soil, caused by the subterranean activities of the crane fly larvae.

When the first field observation was made, late in March, all sizes of larvae of *Nephrotoma ferruginae* were present, with a few pupae. The pupae were protruding slightly above the soil surface. Adults began emerging on April 20 from material placed in cages, and the peak of adult emergence occurred approximately April 25. Second-generation adults were observed in the field during the first week of May.

An application of poisoned bait consisting of calcium arsenate and wheat middlings, 1 to 20 by weight, to which were added molasses and water in sufficient quantities to make a moist, crumbly mass, greatly reduced the number of active crane fly larvae. The bait was sown broadcast over approximately one half of the infested field, leaving the other portion as a check. Three days after the bait was applied, numerous dead larvae were found on the surface of the soil on the treated area, while only living larvae could be found in the check. A week after treatment the surviving plants on the baited area showed but little feeding and no additional plants had died, while in the untreated area the number of dead and dying plants had increased.

W. A. THOMAS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* 8-31-36

Injury to Lumber by *Hadrobregmus carinatus* Say.—During the past winter there was brought to our attention an instance of serious injury of elm joists in a house at Le Center, Le Sueur county, Minn., which proved to be due to the anobiid beetle *Hadrobregmus carinatus*. The infested joists, which had supported a basement floor were eaten through, except for a thin outer shell. Those composed chiefly of sapwood were so badly riddled that it was difficult to recognize structural features. One joist in which the structure was still intact contained some heartwood which was damaged.

A second similar infestation was reported from Wabasha, Minn. Samples sent in July 1936, proved to be of elm sapwood. Since apparently there was no heartwood in the infested sample, whether the beetles had damaged heartwood could not be determined.

The injury done by *Hadrobregmus* closely resembles that caused by *Lyctus* species. The emergence holes are somewhat larger and the frass somewhat coarser.

NELLIE M. PAYNE, *Division of Entomology, University Farm, St. Paul, Minn.* 9-1-36

Potential New Insecticides.—In the search for new insecticides being conducted by the Bureau of Entomology and Plant Quarantine, several hundred synthetic organic compounds have been prepared and tested. Of the compounds tried against codling moth larvae at the Fruit Insect Laboratory, National Agricultural Research Center, Beltsville, Md., the following showed high initial toxicity under laboratory conditions (apple-plug method): *p*-nitroiodobenzene ($C_6H_4INO_2$), thiocoumarin (C_9H_6OS), and phenothioxin ($C_{12}H_8OS$). These compounds are very toxic when freshly applied, but under laboratory conditions they lose much of their effectiveness when exposed as a spray deposit for a week or so. However, derris, pyrethrum, nicotine and other potent and widely used insecticides do likewise. Experiments are in progress to find means to retard or prevent their loss in toxicity, which may be due to slow vaporization, to atmospheric oxidation, or to photochemical decomposition. The pharmacological action of these compounds on mammals is being determined. These compounds are also being tested against various insects of economic importance in other laboratories of this Bureau.

L. E. SMITH, E. H. SIEGLER, and F. MUNGER, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* 9-8-36

Wider Uses for Nicotine.[1]—Successful application of atomized pyrethrum in oil as a horticultural spray has been a recent development in entomology. Use of free nicotine in a similar way is being investigated at the Kentucky Agricultural Experiment Station.

It has been found that free nicotine may be directly incorporated in highly refined petroleum base oil to give a stable solution which does not deteriorate or separate out. This material, containing 1 to 3 per cent nicotine, applied as a fog, has not burned even such tender plants as beans, sweet potato and balsam. In the laboratory, nicotine in oil has

[1] The investigation reported in this note is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

given a high per cent kill of many insects,including such resistant forms as mealy bugs, white fly and adult green June beetles.

Comparative tests of the toxicity of nicotine in oil and pyrethrum in oil have shown that the toxicity of the two materials varies with the species tested. Nicotine in oil is especially toxic to many insects with a high metabolic rate. In Kentucky, free nicotine is more available than pyrethrum and costs considerably less for a toxic equivalent.

Nicotine in oil shows promise as an insecticide in greenhouses, on truck crops and small fruits, and may be adaptable for household use. Its adaptation for orchard use will depend on the development of suitable applicators, the selection of appropriate oils and the development of soluble fungicides.

P. O. RITCHER and R. K. CALFEE, *Kentucky Agricultural Experiment Station, Lexington.*
9-28-36

Observations on Control of Mexican Bean Beetle in Association with Powdery Mildew Disease on Snap Beans.—In conducting experiments for the control of the Mexican bean beetle, *Epilachna varivestis* Muls., on the fall crop of snap beans in eastern Virginia the results are sometimes complicated by powdery mildew disease (caused by one of the Erysiphaceae), which alone is occasionally a serious factor in the production of the crop and when occurring in association with the former adds considerably to the severity of the injury.

During the fall of 1935 at Norfolk, Va., an experiment was being conducted for the control of the Mexican bean beetle in which the sprays and dusts listed below were being tested. SPRAYS.—Magnesium arsenate (2 pounds in 50 gallons of water), commercial barium fluosilicate (3 pounds in 50 gallons of water), synthetic cryolite (3 pounds in 50 gallons of water), and water suspensions of derris and cubé root (rotenone content of sprays .02 per cent). DUSTS.—Synthetic cryolite 60 parts with finely ground dusting sulfur 40 parts by weight, derris–talc, derris–sulfur, cubé root–talc, cubé root–sulfur (each containing .50 per cent of rotenone), and undiluted sulfur dust. Treatments were applied on September 18 and on October 1.

Examination of the plots on September 24 (six days after the first treatment) indicated that powdery mildew fungus was beginning to show on the foliage on all plots except those on which sulfur was used as a diluent for the dusts of cryolite, derris and cubé root. The value of sulfur dusts and sprays in controlling powdery mildew disease on this crop had been previously demonstrated by Cook (1931, Va. Truck Exp. Sta. Bul. 74) as a result of experiments conducted at Norfolk, Va.

Since there was a heavy Mexican bean beetle infestation in the plots, and in view of the fact that sulfur and talc were being compared as diluents for some of the dusts, it was decided to add wettable sulfur at the rate of 2 pounds in 50 gallons of water to each of the sprays at the time of the second treatment (October 1) to avoid complication of the results and to obtain information relative to the control of both the insect and the disease.

The results of the experiment showed that wettable sulfur (2 pounds in 50 gallons of water) added to the various sprays at the time of the second treatment gave good control of the Mexican bean beetle and powdery mildew on foliage and pods. These sprays containing wettable sulfur, however, did not give control of powdery mildew for as long a period as did two applications of a dust mixture of derris cubé root, or cryolite and sulfur. These three dust mixtures gave excellent control of both the Mexican bean beetle and powdery mildew, protection against the latter being equally as effective as when undiluted sulfur dust was used. At the conclusion of the experiment the foliage of the plants in the untreated plots, and in plots treated with derris or cubé root containing talc as a diluent, was completely covered with the white fungus causing the disease, whereas plants in plots that had received treatments containing sulfur (either in combination with the regular sprays or as a diluent for the dusts) remained green and healthy. Also, a large percentage of the pods on plants that failed to receive treatments of sulfur were unmarketable owing to injury resulting from the disease, the pods on such plants being dwarfed, deformed, and badly spotted with reddish brown lesions.

Results of the experiment indicate that in instances where a Mexican bean beetle infestation occurs in association with powdery mildew disease, control of both the insect and the disease may be obtained by the addition of wettable sulfur to the Mexican bean beetle spray, or by the use of sulfur as a diluent for the dust.

LOYD W. BRANNON and NEALE F. HOWARD, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* 9-10-36

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RÔLE OF SECTIONAL MEETINGS

THE increasing number of sectional entomological meetings and conferences leads us to give serious thought to the significance and value of these and the annual meeting of the Association. Equally important to the future development of the science of entomology are the prompt publication of papers and the responsibilities of the entomologist in offering concise and well-prepared manuscripts for publication and in adequately supporting entomological projects. The importance of these items has been repeatedly called to our attention and has been the subject of several editorials, notably in the December 1935 and June 1936 numbers of the JOURNAL.

The sectional *ad interim* meetings are undoubtedly filling a need but they vary notably in their conduct and affiliation. Three are definitely affiliated with the parent Association, maintain a prepared program, and have a place in the JOURNAL for the publication of their papers, thus closely agreeing with the annual meeting of the Association excepting for their sectional character. The group known as the North Central States Entomologists' Conference was organized by four central western states having similar insect problems, as an annual informal clearing house, with no fixed program and no prepared papers for publication, although a mimeographed resumé of the discussions is made available. This group has attracted workers from states with widely different problems and has grown to be one of the largest sectional meetings, in fact to a size that makes increasingly difficult the maintaining of informal discussions, so valuable in the earlier meetings. The Rocky Mountain Entomologists' Conference, conducted during the summer months in a location affording outing facilities, is not unlike the North Central States meeting, except that it is still sufficiently small to maintain its informality and provide outing and recreational facilities so that entire families, rather than entomologists alone, enjoy the meetings.

Study of these several types of meetings emphasizes the value of small, informal, sectional groups, and the Executive Committee of the Association has wisely proposed a study of the entire problem of sectional and other related groups.

Undoubtedly, the annual meeting of the Association must maintain its national scope and a prepared program, because of the size of the gathering. The publication of most of the papers presented is paramount. As has been so often noted, and as the writer has observed after almost uninterrupted attendance for thirty years, the great value derived from

attending the annual meetings is our contacts and exchange of results and ideas with workers from all sections of the United States and Canada. As to the *ad interim* meetings, it would seem wise from the standpoint of usefulness and cost to those attending to have more and smaller groupings, maintain the informal, conference type of meeting, and have a summary of the discussions, rather than entire, individual papers, prepared and published in the JOURNAL.

The vast amount of material which should be published as a permanent record as well as for immediate use is a big problem. Everyone whose vocation is supported from funds provided for entomological work should recognize the great importance of supporting the Association by maintaining paid-up memberships, and inasmuch as the other national organization, The Entomological Society of America, is a material aid to entomologists in the applied field, it should likewise be supported, if for no other reason than that it provides a good outlet for articles in the "pure" field of entomological research. Of the many other projects which warrant the support of entomologists, two of national scope are worthy of specific mention, namely, the Crop Protection Institute and the Thomas Say Foundation.

The question of subsidizing the publications of our national societies is not out of line. The advisability of subsidization from commercial companies, either for giving priority to papers over bona fide members of the Association or for advertising which verges on the style of advertising so common to our general magazines, is a moot question. On the other hand, experiment stations and other similar organizations might well and favorably consider subsidizing our publication to insure prompt printing of research results.

The science of entomology is an endless field wherein remarkable strides have been made in recent years, with increasing opportunities to those well trained and sincerely interested in the work. The Association has recognized the many new problems confronting the science and it is to be hoped that its officers will continue to give adequate and fruitful consideration to these needs.

J. J. DAVIS

Obituary

Clarence Waterman Lewis 1882–1936

Clarence Waterman Lewis died in New York City on August 19, 1936, after 18 years of service in entomological work with the U. S. Department of Agriculture.

Mr. Lewis was born in Melrose, Mass., on July 26, 1882, the son of Frank W. Lewis and Celia S. Brown Lewis. He attended the grammar and high schools of Melrose. He entered the Massachusetts Agricultural College in the fall of 1900, and graduated with a B.S. degree in 1905. During his college years he was a prominent football player, and befriended many poor boys who were working their way through college.

On September 23, 1918, he was appointed special field agent of the Bureau of Entomology, and assigned to gypsy moth work in Massachusetts. During the later years of his life, he was connected with the regulatory work on Japanese beetle control, and assigned to work on domestic quarantines.

As far as we can ascertain, he leaves no close relatives. "Chick" Lewis leaves, however, many very staunch friends in the entomological fraternity.

J. A. HYSLOP. 9-14-36

Review

Forest Insects, *a text for the use of students in forest schools, colleges and universities and for forest workers,* by R. W. Doane, E. C. Van Dyke, W. J. Chamberlin and H. E. Burke. (American Forestry Series.) 1936. 8vo., cloth, xii+463 pp., frontis.+234 figs., bibliog., append., index. McGraw-Hill Book Co., New York City. $4.50.

This volume is an admirably illustrated and readable presentation of the forest-insect problem. It is particularly valuable because of the exceptionally full discussion of the forest problems of the west, though it by no means neglects those of the east. This is especially true of the bark beetles and the ambrosia beetles, forms responsible for huge losses in forests and forest products.

The treatment is primarily by insect groups. The general plan followed is to give a somewhat detailed though summarized account of a typical species with brief mention, mostly in relation to food habits, of a number of associated or related insects. It is only by some such method that it was possible for the authors to include in this relatively small volume notices, mostly brief, of over 1600 species. The bark beetles, presumably on account of their outstanding importance as forest insects, are given more space in comparison with the size of the group than any other insect assembly. The discussions of other beetles are also somewhat more extended relatively than those of other insect groups, though the reviewer recognizes the difficulty in maintaining an entirely satisfactory balance in a work of this character. It includes, in addition to its thoroughly sound discussion of these problems, well-selected bibliographies, both general and special, and an appendix listing under the various food plants the more important insect enemies of the coniferous and hardwood trees of the United States. There is also a detailed index. We regret to note that the volume is marred by an unusually high percentage of minor typographical errors. These, however, do not affect the value of the work materially and doubtless will be corrected in a later edition.

The discussion of the general forest-insect problems and methods of dealing with them is exceptionally satisfactory, indicating the influence of the trained forester as well as the entomologist conversant with insects and their habits. The volume fills a most important place in forest entomology and should prove most helpful to the student, teacher and all interested in forest problems.

E. P. Felt. 9-14-36

Current Notes

On September 1 Dr. L. O. Ellisor joined the staff of the Department of Entomology of the Louisiana Agricultural Experiment Station. Dr. Ellisor was formerly employed by the Bureau of Entomology and Plant Quarantine in the development of larvicides and repellents to control screw-worm fly.

Mr. B. A. Osterberger, assistant entomologist of the Department of Entomology of the Louisiana Agricultural Experiment Station, will be a graduate student this year in the Department of Zoology and Entomology of the Kansas State Agricultural College, where he will work under the direction of Dr. G. A. Dean. Mr. Osterberger is a specialist in sugar cane insects.

Charles L. Smith has received appointment in The McCormick Laboratories, to work under the direction of A. E. Badertscher, on the correlation of methods for determining the toxic value of insecticides, to demonstrate results of the experimental work of the laboratory, and to make biological tests for their customers.

Dr. Lee H. Townsend, formerly assistant entomologist of the Illinois Natural History Survey, Urbana, has accepted a position at the University of Kentucky, beginning September 1. Dr. Townsend will teach economic entomology in the College of Agriculture, Lexington.

AAAS MEETING AT ATLANTIC CITY WILL FEATURE SCIENCE EXHIBITION

In connection with the annual meetings of the AAAS at Atlantic City during the holidays the Annual Science Exhibition will be an unusual feature. The individual exhibitors will include the following: Charles G. Abbot with his improved solar engine, R. J. Ander-

son with his chemicals produced by tuberculosis, W. F. G. Swann with cosmic rays, Arthur H. Compton, Irving Langmuir, Robert A. Millikan, Harold Urey, George B. Pegram, P. I. Wold and Charles T. Knipp.

The institutional exhibitors will include the National Geographic Society, Rural Electrification Administration, Smithsonian Institution and others so far as the space available will permit. The commercial exhibitors will have unusual attractions, for example The Hanovia Chemical and Manufacturing Company will give unusual demonstrations in quartz blowing. All the leading publishers will have booths, the leading American science authors and writers will be in attendance and the science library will contain the science books of 1936 in all fields. The gondola of the now famous stratosphere flight will be placed in the center of the lounge.—F. C. Brown, *Director of Exhibits*

DE LONG NEW DIRECTOR OF STONE LABORATORY

Conversion of the Franz Theodore Stone Laboratory at Put-in Bay, Ohio, from a summer school to a permanent research station of The Ohio State University, was accomplished this summer. D. M. De Long, professor of entomology at Ohio State, will head the research staff as director of the laboratory.

The laboratory will continue as an institution for general biological research and will be operated in connection with the state game and fish hatcheries at the same location.

Dr. De Long retains his professorship at the university but his work there will be assumed by two instructors. Dr. F. L. Campbell, of the Bureau of Entomology and Plant Quarantine, has been appointed associate professor and will have charge of physiologic and toxicological entomology. Ralph H. Davidson, of the university staff, has been advanced to assistant professor in charge of economic, general and medical entomology teaching.

GERMAN INSTITUTE OF ENTOMOLOGY CELEBRATES FIFTIETH ANNIVERSARY

The German Institute of Entomology, clearing house for entomological information in the Reich observes its passing of the half century mark this year. The institute is a branch of the Kaiser Wilhelm Association and is located in Gosslar Strasse in the Berlin suburb of Dahlen. Directors of the institute are Dr. Walther Horn and Dr. Sachtleben. According to a note from Dr. Rolf Reissman, the institute has the largest technical library on the subject of insect study in the world, as well as thousands of specimens and complete equipment for investigation of insects submitted and the handling of inquiries.

CANADIAN, U. S. AND FOREIGN ENTOMOLOGISTS SEE BELLEVILLE PARASITE LABORATORY OPEN

More than 70 entomologists from Canada, the United States and England on June 25 and 26 greeted the staff of the New Ontario Dominion Parasite Laboratory, which opened its doors June 24, 1936, at Belleville.

"Probably the finest of its kind in the world," was the pronouncement of entomologists who viewed the structure.

The laboratory, established in 1929 by the Ontario Department of Agriculture, Entomological Branch, is now the central point at which insect parasites of injurious species will be assembled, studied and reared, and from which they will be liberated at various points in Canada. The work will concern control of insect pests attacking trees and shrubs, fruits and fruit trees, grain, vegetable and garden crops, household and storage insects, and also insects attacking animals and man.

The laboratory was constructed after thorough study of similar institutions throughout the world. It is designed to permit rearing of parasites under any climatic condition necessary with the conditions of each room adjustable as a unit independent of other rooms.

The building, having one story and a deep basement, is in the form of the letter H. Three wings on the ground floor are divided into four rooms and the fourth is undivided. A basement wing of four rooms will be used for insect storage and propagation and two cold-storage rooms occupy a second wing. The rest of the basement is taken up with equipment, including air-conditioning machines, refrigerating machines and boilers.

Construction of the building is of reinforced concrete. Insulation of the walls is cork and of the partitions rock wool. The concrete floors have cork insulation covered with two inches of mastic flooring. Triple glass windows and doors that can be sealed insure air tight conditions for individual fumigations, and an exhaust system conducts gases directly from the room to the outside.

The air, furnished to the rooms through ceiling ducts, is conditioned to temperature and humidity. Air changes are frequent, complete replacement occurring every six to ten minutes. A conditioner is provided for each wing and air cooling is done within the conditioner units. Heating is by an automatic oil furnace and is done partly in the conditioner by thermostats in each room controlling separate radiators. Each room is furnished with vacuum and compressed air for handling insects as well as water and electrical facilities.

Horticultural Inspection Notes

INFESTATIONS of the peach mosaic disease in California, Colorado, New Mexico, Texas and Utah, and of the satin moth of Oregon are under consideration as to quarantine action on the part of the Secretary of Agriculture. Public hearings were set for September 14 at Washington. In case of the satin moth quarantine the advisability of either revoking the present quarantine or extending the restrictions to the state of Oregon will be given consideration.

A *Fusarium* wilt of Mimosa trees, *Albizzia julibrissin*, discovered in Tryon, N. C., and Wysacky, S. C., by Dr. George Hepting, forest pathologist of the U.S.D.A. Bureau of Plant Industry, is the subject of a series of regulations, promulgated July 27, 1936, by the North Carolina Board of Agriculture, which prohibits the movement of Mimosa trees from the township in which the town of Tryon is located to any other part of North Carolina. The regulations also permit the removal of infected trees.

According to R. W. Leiby, plans are under way for the cutting down of all Mimosa trees recognized as being infected with the wilt disease in North Carolina. The work to be done before winter. Tryon is a mid-south winter resort with more than average pride in its horticultural plantings. The Mimosa is its leading ornamental tree.

Perhaps 5 per cent of the Mimosa trees in Tryon are wilt affected. The disease has been known to be present for about three years. Two or three years appear to be required to kill a tree, once it becomes infected with the disease.

The following editorial appeared in the July 28 issue of the Raleigh *News and Observer* under the heading "Threat to Mimosa."

> Undoubtedly wise is the regulation empowering the Division of Entomology of the state Department of Agriculture to remove Mimosa trees found in the town of Tryon, and in other parts of the state affected with a new Mimosa wilt disease, and to prohibit the movement of Mimosa trees, cuttings and roots within the state. At the same time North Carolinians who at this season rejoice in the beauty of the Mimosa will hope that the wilt against which action is taken will not reach serious proportions. There is no lovelier tree of the summer time than the Mimosa, unless it be the crape myrtle which blooms beside it. And such beauty is entitled to the prompt action which the Board of Agriculture has taken.

Weevils were found in the Wyoming counties of Niobrara, Converse, Carbon and Uinta. These have all been previously reported as infested but have not been examined for weevil occurrence for several years.

LEMONS GROWN in California may enter Arizona provided the fruit and the picking containers have been submerged in a liquid insecticide and the shipment is so certified, according to an amendment of the Arizona citrus quarantine approved July 9.

OWING PRINCIPALLY to emphasis necessarily placed on other phases of alfalfa weevil research in 1936, it was possible for the federal Bureau to undertake only a limited amount of scouting for new infestations. Such scouting was mostly incidental to other research activities. This resulted in the discovery of previously unreported infestations in Eagle county, Colo.; Dawes and Box Butte counties, Neb.; Harney county, Ore.; Fall River county, S. D.; and Daggett county, Utah. The infestation observed in Fall River county, S. D., which adds a new state to infested territory, is well established and apparently represents natural spread of the insect from the immediately adjacent Sioux county, Neb., where a well-marked infestation has existed for some time.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

PROCEEDINGS OF THE ELEVENTH ANNUAL MEETING OF THE COTTON STATES BRANCH

The eleventh annual meeting of the Cotton States Branch was held at Jackson, Miss., February 5 and 6, 1936, as the entomology section of the thirty-seventh annual convention of the Association of Southern Agricultural Workers. The attendance was larger than that of any previous meeting of the Branch, and all of the available time was required for the interesting program, which dealt with insects attacking animals, and truck, cotton, fruit and other crops grown in the southern region. Informal discussions followed the presentation of a number of the papers, which brought out additional points of interest. The papers on the program were classified as follows: Insects injurious to cotton 12, insects injurious to truck crops 7, insects injurious to animals 5, insects injurious to tobacco 2, insects injurious to corn 1, household insects 1, insects injurious to peaches 1, insects injurious to pecans 1, insects injurious to rice 1, and parasites 2.

The president of the American Association of Economic Entomologists appointed Dr. F. L. Thomas, chief of the Division of Entomology of the Texas Agricultural Experiment Station, as the official representative of the parent Association at the annual meeting of the Branch in Jackson, Miss., and he attended in that capacity. Mr. S. A. Rohwer, assistant chief, and heads of four divisions of the U. S. Bureau of Entomology and Plant Quarantine attended the meeting. Greetings from Mr. Strong, chief of the Bureau, were extended to the Branch by Mr. Rohwer, who also reported on the St. Louis meeting of the parent Association and discussed the new publication policy and other matters of business transacted at St. Louis. The secretary discussed the pressing needs for publication and requested the Branch to adopt a new publication policy. The purpose of the Branches and the type of program for future meetings were discussed at the final business session.

The members of the Cotton States Branch and all delegates to the annual convention of the Association of Southern Agricultural Workers were guests at a banquet on February 5. On the following night Governor White of Mississippi and Mrs. White gave a reception at the mansion for the members of the several agricultural organizations meeting in Jackson.

BUSINESS PROCEEDINGS

The meeting was called to order by Chairman Clay Lyle at 2 p.m. on February 5 in the Edwards Hotel at Jackson, Miss. The following were present:

J. P. Amsler, Forrest, Miss.
O. G. Anderson, Louisville, Ky.
W. E. Anderson, Baton Rouge, La.
G. A. Bieberdorf, Stillwater, Okla.
F. C. Bishopp, Washington, D. C.
Theo. L. Bissell, Experiment, Ga.
G. L. Bond, Moss Point, Miss.
G. C. Broome, Jr., Hattiesburg, Miss.
M. Brunson, Hattiesburg, Miss.
E. K. Bynum, Houma, La.

O. C. Cartwright, Clemson, S. C.
F. S. Chamberlin, Quincy, Fla.
J. C. Clark, Tallulah, La.
K. L. Cockerham, Biloxi, Miss.
R. P. Colmer, State College, Miss.
L. F. Curl, Miami, Fla.
N. L. Douglass, Grenada, Miss.
E. W. Dunnam, Leland, Miss.
P. T. Eaton, Baton Rouge, La.
K. P. Ewing, Port Lavaca, Texas.
Alfred Fenton, Houston, Texas.
B. M. Gaddis, Washington, D. C.
R. C. Gaines, Tallulah, La.
G. L. Garrison, Tallulah, La.
Paul M. Gilmer, Tallulah, La.
H. Gladney, Ocean Springs, Miss.
L. J. Goodgame, Aberdeen, Miss.
A. L. Hamner, State College, Miss.
R. W. Harned, Washington, D. C.
P. K. Harrison, Baton Rouge, La.
M. M. High, Biloxi, Miss.
W. R. Horsfall, Monticello, Ark.
J. B. Hull, Savannah, Ga.
J. W. Ingram, Houma, La.
M. P. Jones, Washington, D. C.
J. P. Kislanko, Wiggins, Miss.
E. F. Knipling, Valdosta, Ga.
E. W. Laake, Valdosta, Ga.
J. M. Langston, State College, Miss.
Horace Lee, Tallulah, La.
J. E. Lee, Popularville, Miss.
M. D. Leonard, New York, N. Y.
Clay Lyle, State College, Miss.
R. E. McDonald, San Antonio, Texas.
E. R. McGovran, Valdosta, Ga.
Paul Miller, Little Rock, Ark.
Jack Milton, Jackson, Miss.
H. S. Moles, Baton Rouge, La.
L. A. Niven, Memphis, Tenn.
B. A. Osterberger, Baton Rouge, La.
N. D. Peets, Brookhaven, Miss.
L. H. Pough, St. Louis, Mo.
W. J. Reid, Jr., Charleston, S. C.
R. C. Roark, Washington, D. C.
S. A. Rohwer, Washington, D. C.
A. L. Scales, Tallulah, La.
Ernest E. Scholl, Stillwater, Okla.
W. A. Shanks, Oxford, N. C.
W. A. Simanton, Pittsburgh, Pa.
C. E. Smith, Baton Rouge, La.
F. A. Smith, Senatobia, Miss.
G. L. Smith, Tallulah, La.
Oliver Snapp, Fort Valley, Ga.
Chas. L. Stracener, Baton Rouge, La.
J. O. Tacket, Jackson, Miss.
F. L. Thomas, College Station, Texas.
J. N. Todd, Clemson, S. C.
W. F. Turner, Atlanta, Ga.
W. H. White, Washington, D. C.
C. B. Wisecup, Sanford, Fla.
G. I. Worthington, Cleveland, Miss.
M. S. Yeomans, Atlanta, Ga.
H. T. Young, State College, Miss.
M. T. Young, Tallulah, La.

The report of the secretary-treasurer was then read and approved subject to the audit of the auditing committee.

REPORT OF THE TREASURER

Balance on hand February 1, 1935		$193.64
Refund from parent Association for postage and printing during year ending Jan. 31, 1935		20.20
1932 annual dues from 1 member		1.00
1933 annual dues from 2 members		2.00
1934 annual dues from 3 members		3.00
1935 annual dues from 20 members		20.00
1936 annual dues from 6 members		6.00
Interest on deposit in Savings Department of First National Bank, Altanta, Ga.		1.90
Paid out:		
Expense for annual meeting in Atlanta (By action of Executive Committee)	$ 15.95	
Stamped envelopes and stamps	13.87	
Printing announcements and programs	7.00	
	$ 36.82	$247.74
Balance on hand February 1, 1936	$210.92	

REPORT OF THE SECRETARY

The number of members in the Cotton States Branch on December 31, 1935, was 174 There was a net decrease of 25 members during the year, after removing the names of those who moved out of the Branch territory or were dropped by the parent Association for nonpayment of dues. There has been a gradual decrease in the membership since 1930,

when there were 237 names on the roll, but the present membership is still greater than that of 1926 when the Branch had only 158 members.

The number of members by states on December 31, 1935, was as follows: Texas 39, Mississippi 28, Louisiana 26, Florida 17, Georgia 15, North Carolina 12, South Carolina 12, Tennessee 9, Alabama 7, Arkansas 6, and Oklahoma 3. South Carolina with a net increase of one member was the only state to show an increase in membership during the year. There was no change in the number of members in Georgia during the year. The following states showed net decreases during the year: Florida 7, Texas 6, Mississippi 4, Louisiana 3, Alabama 2, Arkansas 1, North Carolina 1, Oklahoma 1, and Tennessee 1. There are several hundred entomological workers in the 11 cotton states who are not members of the American Association of Economic Entomologists, and members of the Branch are requested to urge these men to file application for membership in the parent Association. Lists of these workers will be gladly furnished upon application to the secretary of the Cotton States Branch.

The secretary sent to each member of the Branch an invitation to participate in the regular annual meeting in Jackson, Miss., on February 5 and 6, 1936. The program for that meeting was mailed to each member on January 22. The proceedings of the tenth annual (Atlanta) meeting of the Cotton States Branch were published in the October, 1935 (Vol. 28, No. 5) issue of the JOURNAL OF ECONOMIC ENTOMOLOGY, and a report on the ninth annual (Memphis) meeting was published in February, 1935 (Vol. 28, No. 1) issue of the JOURNAL.

Annual dues in the Cotton States Branch are $1. Twenty-five of the 174 members have paid dues for 1935, and only seven members have paid their 1936 dues, which are now payable.

APPOINTMENT OF COMMITTEES

Chairman Lyle appointed the following committees: Resolutions—F. L. Thomas, B. A. Osterberger and K. P. Ewing; auditing—K. L. Cockerham, T. L. Bissell and W. E. Anderson; nominations—M. S. Yeomans, R. W. Harned and R. P. Colmer; executive (pro tem)—F. L. Thomas and W. E. Anderson; publication policy—Oliver Snapp, F. L. Thomas and A. L. Hamner.

Chairman Lyle called for the report of committees.

REPORT OF RESOLUTIONS COMMITTEE

The following resolutions were duly adopted after reading of the report of the Committee on Resolutions, and the secretary sent them to the parties concerned:

Be It Resolved, That the membership of the Cotton States Branch in annual meeting assembled at Jackson, Miss., express its appreciation and extend thanks to the Committee on Local Arrangements for its efforts in assuring the success of our meetings and the comfort and entertainment of the members.

Resolved, That we also express our thanks to the management of the Edwards Hotel for the facilities and accommodations provided.

Resolved, That since we feel deeply indebted for the large number of papers given by members of the Bureau of Entomology and Plant Quarantine, we send expression of our gratitude to the chief of the Bureau for these and other contributions which have added so much to the success of these meetings.

Whereas, The Cotton States Branch has recently lost, through the death of Doctor W. E. Hinds, one of its oldest, most distinguished, and most influential of its members, and

Whereas, This loss is keenly felt by the entire membership,

Be It Resolved, That we hereby stand for a moment in silence as a tribute to his memory, and that expression of sympathy be sent to Mrs. Hinds and read into the minutes of this Branch.

REPORT OF AUDITING COMMITTEE

The Auditing Committee reported that the books and accounts of the Branch had been carefully audited, and found to be correct. This report was then adopted by motion and vote and a certificate given to the secretary-treasurer.

REPORT OF COMMITTEE ON PUBLICATION POLICY

The following report of the Committee on Publication Policy was adopted by motion pending action of the parent Association:

In view of the pressing needs for publication and because of the limitation of 50 printed

pages allowed each Branch by the parent Association, this committee believes that the publication of papers in the proceedings of the annual meeting of the Cotton States Branch be given preference in the following order:

(1) Members presenting their paper in person.
(2) Members presenting two or more papers in person.
(3) Titles not sent to the secretary before the expiration of the time limit as specified by the by-laws and indicated in the announcement sent out by the secretary.
(4) Papers read by person other than the author.
(5) Papers read by title.
(6) Papers by nonmembers.

Furthermore, the committee recommends that in case the number of printed pages resulting from the publication of papers that come under the first classification be greater than 50, that

(1) The printed pages be prorated according to the number of papers presented.
(2) The additional number of printed pages of each paper be paid for by the author or authors.

REPORT OF EXECUTIVE COMMITTEE

The Executive Committee recommends that in order to make the meetings of the Cotton States Branch more accessible to entomologists in Texas and Oklahoma, future meetings of this Branch be held annually in the following order:

West of the Mississippi
On the Mississippi
East of the Mississippi
On the Mississippi

and that whenever possible the meeting be held in conjunction with the Association of Southern Agricultural Workers.

This report resulted in considerable discussion and finally by motion and vote the whole matter of future meetings of the Branch was left to the Executive Committee with power to act. Adoption of the plan recommended by the Executive Committee was favored by the Branch provided it met with the approval of the Texas Entomological Society.

REPORT OF NOMINATIONS COMMITTEE

The Nominations Committee recommended the following names for officers during the ensuing year: Chairman—W. E. Anderson, Baton Rouge, La.; vice chairman—W. E. Dove, San Antonio, Tex. By motion and vote the secretary was instructed to cast a single ballot for the unanimous election of these officers, and past chairmen Harned and Thomas escorted Mr. Anderson to the chair, where he was duly installed. Secretary-treasurer Oliver Snapp was elected in 1934 for a three-year term.

By motion and vote the secretary was requested to do everything possible to get all unpublished papers of previous meetings published during 1936.

PAPER-READING SESSION

The session for addresses and presentation of papers convened immediately following the business session, with Chairman Lyle presiding.

USED ENGRAVINGS FOR SALE

Engravings of illustrations which have appeared in Volume 29 of the JOURNAL may be purchased by the respective authors or their representatives at one-half cost price. Beginning August 1935, if engravings are not wanted within thirty days from date of publication, they will be destroyed.

Orders to ship engravings to authors should be sent to the editor, from whom cost prices may be obtained. Authors will be billed for purchased engravings plus mailing charges by the business manager of the Association.

This does not apply to engravings for articles for which the costs of publication are paid by authors or their representatives. Such engravings will be shipped to authors at their direction if ordered within thirty days from publication; otherwise they will be destroyed.

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COPIES OF ASSOCIATION ROSTER NOW AVAILABLE

The 1936 official roster of the American Association of Economic Entomologists has been reprinted and will be distributed to those members who attend the annual meeting at Atlantic City, in accordance with past practice. Nonmembers of the Association who want a copy of this list may secure it by applying to the secretary, Ernest N. Cory, College Park, Md., enclosing 50 cents for each copy desired. The list contains 23 pages and includes names of the officers, standing committees, representatives to allied organizations, and the list of members.

AMERICAN ASSOCIATION

of

ECONOMIC ENTOMOLOGISTS

PROGRAM

Forty-ninth Annual Meeting

Atlantic City, N. J.

December 28–31, 1936

Forty-ninth Annual Meeting of the American Association of Economic Entomologists Atlantic City, N. J.

December 28–31, 1936

All sessions of the annual meeting will be held in Haddon Hall, which is the Association headquarters.

The Entomological Society of America will hold its meetings on the same floor of Haddon Hall on December 28 and 29.

The public address of The Entomological Society of America will be the feature of the Entomologists' Dinner to be held on Tuesday night at 6 p.m. Dr. Edith M. Patch will deliver the public address.

Exhibits will be staged in the Mandarin room. Meetings of the Entomologists will be in the Viking room, the Entomological Society will meet in the Benjamin West room, and sectional meetings will be held in the Tower room when they coincide with either of the society sessions.

PROGRAM

J. G. SANDERS, Chairman of Program Committee

Monday, December 28

SECTION OF APICULTURE

9:30 a.m., Tower Room

W. J. NOLAN, Chairman W. A. PRICE, Secretary

Appointment of Committee on Resolutions and Nomination.

Address of the Chairman. Modified Technic for the Watson Method. W. J. NOLAN, Washington, D. C.

1. Qualifications of State Apiary Inspectors. G. M. BENTLEY, Knoxville, Tenn.

Suggestions for the uniformity of state apiary inspectors, with an outline of the qualifications, and form of reports which should be made of the apiaries.

2. Recent Apiary Inspection Developments in Wisconsin. E. L. CHAMBERS, Madison, Wis.

3. Preliminary Report on American Foulbrood Studies in New Jersey. ROBERT S. FILMER, New Brunswick, N. J.

4. Honeybees that Resist American Foulbrood. O. W. PARK, FRANK C. PELLETT and F. B. PADDOCK, Ames, Iowa.

5. Notes on Wintering Bees in Minnesota. M. C. TANQUARY, St. Paul, Minn.

6. A Further Contribution to the Study of Pollen Substitutes. MYKOLA H. HAYDAK, St. Paul, Minn.

7. The Alleged Vitamin E Content of Royal Jelly. HERBERT M. EVANS, GLADYS A. EMERSON and J. E. ECKERT, Davis, Calif.

Royal jelly or its ether-soluble fraction has no vitamin E activity when administered to female rats of proved sterility. This finding failed to confirm the work of Hill and Burdett.

8. The Relation of Size to Fecundity in Queen Honeybees. J. E. ECKERT, Davis, Calif.

9. Equipment for the Honey House. EDWIN J. ANDERSON, State College, Pa.

Convenient and efficient equipment for handling extracted honey is described. This equipment shows an entire program of extracting, heating and straining from the time the honey is taken from the comb until it is ready for the 60-pound cans. The heating of honey in containers and rendering of beeswax is also described.

10. Nutrition Studies with Adult Bees. (8 min., lantern.) R. M. MELAMPY and S. E. MCGREGOR, Baton Rouge, La.

Fresh pollen is a better supplement from the nutritional standpoint to honey than cereals or yeast concentrates. Low relative humidities tend to lengthen the life of bees. Bees live longer when fed 50 per cent sucrose than when fed 10 per cent sucrose or bee candy under the same environmental conditions.

11. The Sugar Concentrations of Some Western Nectars. GEO. H. VANSELL and H. A. SCULLEN, Davis, Calif.

Twenty-eight miscellaneous plants with their nectar concentrations are tabled, as well as 11 varieties of plums. Bee visitation is coupled closely with nectar concentrations.

Reports of Committees.

Selection of Officers.

Closing Business.

GENERAL SESSION

12 noon, Viking Room

Call to Order by the President.

Appointment of Committees on Constitution, Resolutions and Nominations.

Presidential Address. Entomology in Relation to Industry. LEONARD S. MCLAINE, Ottawa, Can.

2:30 p.m., Viking Room

Joint Session with The Entomological Society of America. Symposium on Insects Affecting Man. L. O. HOWARD presiding.

Mosquitoes and Their control. T. J. HEADLEE, New Brunswick, N. J.

Discussion Leader, ROBERT GLASGOW, Albany, N. Y.

Mosquitoes and Malaria. L. L. WILLIAMS, U. S. Public Health Service.

Discussion Leader, F. C. BISHOPP, Bureau of Entomology and Plant Quarantine.

Myiasis of Man. W. E. DOVE, Bureau of Entomology and Plant Quarantine.

Discussion Leader, O. R. CAUSEY, Johns Hopkins University, Baltimore, Md.

Some Therapeutic Uses of Insects and Their Products. WILLIAM ROBINSON, Bureau of Entomology and Plant Quarantine.

Discussion Leader, W. A. RILEY, St. Paul, Minn.

Ticks in Relation to Man. R. R. PARKER, U. S. Public Health Service.

Discussion Leader, ROBERT MATHESON, Ithaca, N. Y.

EXECUTIVE COMMITTEE MEETING

7:30 p.m., Green Room

Reports of Committees other than those Scheduled for the Final Business Session.

SECTION OF EXTENSION SERVICE

7:30 p.m., Tower Room

R. R. REPPERT, Chairman A. D. WORTHINGTON, Secretary

1. Cotton Seed Treatment in Relation to Long-standing Boll Weevil-control Recommendations. W. C. NETTLES, Clemson College, S. C.

2. The Effects of the 1936 Drought on Boll Weevil Population in Oklahoma. C. F. STILES, Stillwater, Okla.

3. Intensive Demonstrations in Cotton Flea Hopper Control. R. R. REPPERT, A & M College, Tex.

4. The Value of a Knowledge of Insect Life to American Youth. A. B. GRAHAM, U. S. Department of Agriculture, Washington, D. C.

5. The Value of Insect Surveys as an Extension Activity. A. D. WORTHINGTON, State College, Ames, Iowa.

6. Further Work in the Instruction of Entomology in 4-H Club Camps in Missouri. GEORGE D. JONES, Columbia, Mo.

7. Value of Coordination of Extension Entomology and the Bureau in Conducting Insect Control Campaigns. P. N. ANNAND, Bureau of Entomology and Plant Quarantine.

8. Opportunities for Extension Work on Insect Problems of the Home. G. E. LEHKER, Lafayette, Ind.

9. Argentine Ant Eradication with WPA Funds. CLAY LYLE, A & M College, Miss.

10. A Large-scale Demonstration in Mosquito Control. ERNEST N. CORY and S. L. CROSTHWAIT, College Park, Md.

11. Iowa Spray Schedule and Survey Based upon Codling Moth Traps Operated by Growers. ROY HANSBERRY, State College, Ames, Iowa.

12. A Summary of Extension Work in Entomology in 1936. M. P. JONES, U. S. Department of Agriculture, Washington, D. C.

Tuesday, December 29

OPENING BUSINESS SESSION

9:30 a.m., Viking Room

Reports of Executive Committee and Secretary.

Report of the Nominating Committee on Nominees to Standing Committees.

Election of Nominees.

1. Recent Data on the Dissemination of Insects by Air Currents. (10 min.) E. P. FELT, Stamford, Conn.

A summation of the past season's data in relation to insects and their dissemination by air currents.

2. Climatic Influence on Insects in Missouri. (5 min.) LEONARD HASEMAN, Columbia, Mo.

In the past three years Missouri has experienced extremes of summer heat and scarcity of rainfall unparalleled in the history of the state, at least since organized entomological research work has been under way. These extremes of climate have had profound influence on our insect populations and have materially affected our control programs. Each species of insect thrives best within a definite range of temperature and moisture, and variations in either direction from this optimum condition retard its rate of development. The past three summers have supplied extreme conditions both as regards high temperatures and low rainfall and they have had varying effects on some of our dominant pests, codling moth, red spiders, chinch bugs, grasshoppers and Hessian fly.

3. Flight Range and Longevity of Floodwater Mosquitoes in the Lower Columbia River Valley. (8 min.) H. H. STAGE, C. M. GJULLIN and W. W. YATES, Portland, Ore.

Aedes vexans Meig. and *A. aldrichi* Dyar & Knab have been stained with aqueous solutions of eosin and methylene blue shortly after emergence and recaptured at later dates. Information has been obtained on the rate and distance traveled, and longevity.

4. Some Mosquitoes of Southeastern Arkansas. (5 min.) W. R. HORSFALL, Fayetteville, Ark.

This is a discussion of various species of mosquitoes which were collected as larvae and adults during 1935 and 1936. A report of species is given together with an appraisal of relative economic importance.

5. European Corn Borer Egg and Larval Populations of Sweet Corn in Relation to Time of Planting. (5 min.) MORRIS SCHLOSBERG and RALPH MATHES, Toledo, Ohio.

Resultant egg and larval populations of experimental seasonal plantings of sweet corn at Toledo, Ohio, in 1934, 1935 and 1936 are compared.

6. Resistance of a Single-cross Hybrid Strain of Corn Against Natural Infestation by the European Corn Borer. (4 min., lantern.) L. H. PATCH, Maumee, Ohio.

The borer populations, the numbers of eggs laid, leaf areas, tasseling and silking dates, and percentages of moisture at harvest, of 10 plantings of a borer-resistant strain are compared with a borer-susceptible strain of nearly the same maturity.

7. Variations in Amount of Feeding by the Southern Corn Root Worm and the European Corn Borer on Corn. (By title only.) L. L. HUBER, Wooster, Ohio.

This paper points out quantitative differences in the amount of feeding by these two insects on several corn hybrids and varieties. The data indicate that the differences are due to physiological causes.

8. A New Pest of Alfalfa. (7 min.) L. O. Ellisor and L. T. Graham, Baton Rouge, La.

Anticarsia gemmatilis, the velvet bean caterpillar, commonly called the soy bean caterpillar in Louisiana, destroyed a major portion of the alfalfa crops during the late summer and fall in Louisiana. The egg parasites, *Trichogramma*, and a fungus were factors in reducing the infestation in some areas. Thus far control is limited to poison control on fall seedlings, and in the delay of fall plantings to prevent defoliation by the caterpillar.

9. Periodical Cicada. (10 min., lantern.) Ernest N. Cory, College Park, Md.

A class project was conducted on Brood X to check the biology as described in the literature and to develop through experimental data and observations the causes of some of the phenomena.

10. The Periodical Cicada. (15 min., motion picture machine.) J. A. Hyslop, Washington, D. C.

A motion picture with "talkie" lecture.

11. Feeding Predetermined Doses of Poison to Silkworm Larvae. (10 min., lantern.) J. W. Bulger, Beltsville, Md.

This is an account of successful administration of predetermined minimum lethal doses of poisons to silkworms, in the form of leaf sandwiches. The method has proved very valuable in toxicological studies on the silkworm.

12. Geographical Center of Entomologists of Continental United States. (3 min., lantern.) F. M. Wadley, Washington, D. C.

The center of population of the two national entomologists' organizations was located, by Census Bureau methods, in southern Illinois.

1:30 p.m., Viking Room

13. The Uses of Illustrative Material in Presenting Subject Matter. (15 min., lantern.) M. P. Jones, Washington, D. C.

Lantern slides and charts will be used to show fallacy of trying to present too much material at one time.

14. A Reproduction Phenomenon Affecting the Propagation of Scale Parasites. (10 min., lantern.) S. E. Flanders, Riverside, Calif.

In certain chalcidoids mated females do not produce males, yet males are necessary for the production of females. The recognition of this fact greatly modified the technic of rearing and liberating such parasites.

15. The Importation into the United States and Puerto Rico of Certain Coccinellid Enemies of Soft Scales. (10 min.) S. M. Dohanian, Somerville, Mass.

The collection of several species of coccinellid predators on certain soft scales in Trinidad, B. W. I.; their shipment into Puerto Rico, Florida and California; and notes on their establishment, are discussed in this paper.

16. The Effect of Insecticides on the Beneficial Coccinellid *Hippodamia convergens* Guer. (15 min., lantern.) Gordon W. Haug and Alvah Peterson, Columbus, Ohio.

A number of common insecticides, stomach and contact poisons, have been tried on the several stages, eggs, larvae and adults of a common coccinellid under greenhouse and laboratory conditions. In some instances the materials have produced decided kill.

17. Introducing More Parasites to Control the Sugar Cane Moth Borer. (10 min.) S. M. DOHANIAN, Somerville, Mass.

Explorations in the American tropics produced several new and efficient parasites of *Diatraea saccharalis*. Their collection, rearing and introduction into Puerto Rico and the United States is detailed in this paper.

18. Effect of Certain Codling Moth Spray Schedules on Other Orchard Insects. (7 min., lantern.) C. R. CUTRIGHT, Wooster, Ohio.

Phenothiazine, alone and with fungicide, and oil–ortho nicotine with fungicide were used throughout the season in comparison with lead arsenate as a control for codling moth. Eight standard varieties of apples were included in each treatment. Control of codling moth was best in the lead arsenate plots. Plum curculio caused severe damage in all plots treated with oil–ortho nicotine, and phenothiazine. European red mite was controlled by the regular schedule of lead arsenate and lime sulfur and by the oil–ortho nicotine, but damage on phenothiazine plots equalled that on unsprayed checks. Figures on the control of apple maggot are not conclusive but indications are that both oil–ortho nicotine and phenothiazine are not satisfactory. Green apple aphis was held in check by ortho nicotine, and the population somewhat reduced by phenothiazine. Other insects are mentioned briefly.

19. Tests on Baits for Oriental Fruit Moth, 1936. (By title only.) S. W. FROST, Arendtsville, Pa.

20. Control Studies of the Citrus Red Mite, *Paratetranychus citri* McG. (10 min.) A. M. BOYCE and D. T. PRENDERGAST, Riverside, Calif.

Laboratory and field experimental procedures employed in the study of this problem are outlined together with a summary of results obtained with various materials. The regularly used highly refined oil sprays are generally very effective; however, *Selocide*, a proprietory selenium compound at 1:800 plus light-medium oil at 1:300 plus 1 pound of sulfur and 3 ounces of sodium caseinate per 100 gallons of spray mixture, also affords satisfactory control.

21. A Laboratory Apparatus for Fumigation with Low Concentrations of Nicotine with Studies on Aphids. (10 min., lantern.) H. H. RICHARDSON, Beltsville, Md.

A glass apparatus with two separate chambers for confining the insects during fumigation is described. Compressed air measured by flow meters is used for the vaporization and dilution of the nicotine. Ground-glass joints are used at all connections through which the nicotine passes. Concentrations of nicotine as low as one-fourth part nicotine per million parts of air or less can be obtained. The nicotine concentration was determined by chemical analysis of the vaporized nicotine. Aphids proved to be very susceptible to nicotine; concentrations as low as 1 part nicotine per million of air for one-half hour exposure at 75° F and 0 per cent relative humidity being sufficient to give high kill. Relative humidity appeared to be a factor affecting efficiency; higher mortality resulting at the lower relative humidity.

22. Autogiro Spraying Experiments. (5 min., lantern.) S. F. POTTS, New Haven, Conn.

Woodland experiments with an autogiro indicated that it was capable of greater safety, slower speed, and better control of insecticidal distribution than an airplane. A spray mist, using concentrated insecticidal mixtures containing an adhesive was much more effective against forest insects than dust.

23. Laboratory Studies on the Adherence and Rate of Settling of

Lead Arsenate Dusts for Autogiro and Airplane Application. (12 min., lantern.) C. C. HAMILTON, New Brunswick, N. J.

Laboratory studies were conducted to determine the adherence to oak foliage of lead arsenate, when mixed with various proportions of different kinds of oil. Studies were also conducted to develop a dust which would flow reasonably free, which would adhere and which would have a minimum amount of drifting.

24. Evaluation of Data on the Effectiveness of Sprays in the Control of Scale Insects. (By title only.) RALPH H. SMITH, Los Angeles, Calif.

The paper deals with the reliability of random counts made to determine the percentage of insects killed by spray treatments, with the applicability of statistical methods in interpretating data thus obtained, and is based upon extended investigations on the effectiveness of sprays in the control of black and red scales of citrus trees.

25. Preliminary Report of Studies with Dinitro-ortho-cyclohexylphenol. (10 min.) A. M. BOYCE, C. O. PERSING, D. T. PRENDERGAST and J. W. HANSEN, Riverside, Calif.

A study of the chemical and physical properties of this nitro pheno compound as they may apply to its possible use in sprays and dusts is in progress and certain of the results obtained to date are reported. Laboratory and field experiments have shown that this compound offers promise for use on citrus, particularly in the control of the citrus red mite, *Paratetranychus citri* McG., the citrus thrips, *Scirtothrips citri* (Moult.), and the greenhouse thrips, *Heliothrips haemorrhoidalis* Bouch, when applied as a dust. It is also being used experimentally in sprays and dusts in the control of several species of lecanium scale insects and the orange tortrix, *Argyrotaenia citrina* Fern.

26. The Contact Insecticidal Properties of Various Derivatives of Cyclohexylamine. (10 min., lantern.) C. W. KEARNS, Urbana, Ill. C. P. I. Project.

A systematic exploratory survey of numerous derivatives of cyclohexylamine has resulted in the development of several compounds highly toxic to insects. This paper is concerned chiefly with the laboratory phase of the investigation. The relative toxicity of the various derivatives to the aphid *Myzus porosus* Sanderson, and to the common greenhouse red spider are represented by toxicity curves. The relationship of toxicity to the substitution of various alkyl, acyl, aryl, aralkyl, or miscellaneous groups on the nitrogen atom of the parent compound is discussed in detail.

ENTOMOLOGISTS' DINNER

6 p.m., Haddon Hall

Public Address of The Entomological Society of America. DR. EDITH M. PATCH, Orono, Me.

Members of the Association who are registered at Haddon Hall (American plan) will be credited with the $2 price of the banquet ticket.

Wednesday, December 30

GENERAL SESSION

9:30 a.m., Viking Room

27. Studies on Soaps and Lead Arsenate in Soft and Hard Waters. (15 min., lantern.) J. M. GINSBURG, New Brunswick, N. J.

Experiments were conducted with lead arsenate with soluble and insoluble soaps in soft and hard waters to determine to what extent soaps may safely be used as spreaders with arsenical sprays. The following results were obtained. Water-soluble soaps increase the soluble arsenic in soft water in proportion to the amount of soap added. Hard waters form large amounts of soluble arsenate, proportional to the degree of hardness. Soluble soaps, added to hard water, prevent the formation of excessive amounts of soluble arsenic. Soluble soaps react with the salts present in hard water, precipitating the corresponding insoluble soaps which apparently do not affect the lead arsenate. Certain insoluble soaps when added directly to the lead arsenate also prevent formation of water-soluble arsenic in hard water. Of the various salts causing hardness in water the bicarbonates and carbonates are primarily responsible for the production of soluble arsenic from lead arsenate.

28. Some Methods and Equipment for Laboratory Studies of Insecticides. (15 min., lantern.) HAROLD WATERS, Columbus, Ohio. Sherwin-Williams Research Project.

A study was made on methods and equipment for rearing test insects and food plants under controlled and standardized conditions that can be maintained throughout the year. An efficient method for growing certain types of plants in trays under controlled conditions, an automatic method for watering these plants, methods for rearing several species of test insects, several new types of insect cages, and methods of determining the toxicity of certain types of insecticides to insects were developed.

29. Some Studies on Calcium Arsenate. (10 min., lantern.) HAROLD WATERS and EUGENE WITMAN, Columbus, Ohio. Sherwin-Williams Research Project.

An attempt was made to determine the factors involved in the formation of the so-called "safe" type of calsium arsenate, and to develop a simple method of making this material. A method was developed, tried on factory scale and found to be satisfactory. A rapid laboratory test for arsenical injury to plants was developed and used extensively. The comparative toxicity of the "safe" and "ordinary" types of calcium arsenate to several insect species was studied.

30. Progress Report on Stickers used with Calcium and Zinc Arsenates. (5 min., lantern.) FRANKLIN SHERMAN III, East Lansing, Mich.

A comparison of the performance of various arsenical-sticker combinations on replicated field plots.

31. Stickers and Spreaders used in Lead Arsenate Sprays for Codling Moth Control (10 min., lantern.) S. W. HARMAN, Geneva, N. Y.

A comparison of the effectiveness of lead arsenate sprays on codling moth control when used with *Goulac*, soybean flour, milk powder and fish-oil soap.

32. Five Years' Experiments with Lead Arsenate–Summer Oil in Codling Moth Control. (12 min., lantern.) B. F. DRIGGERS, New Brunswick, N. J.

Comparative tests of commercial and home-made summer oils used with lead arsenate for the control of codling moth on apples. Worm control and effect on the tree is compared to lead arsenate–lime. Data indicates oil–lead arsenate more effective than lead arsenate–lime in controlling codling moth in heavily infested orchards.

33. The Effect of Light Traps upon a Codling Moth Infestation—A Consideration of Four Years' Data. (10 min., lantern.) DONALD L. COLLINS and WILLIAM MACHADO, Ithaca, N. Y.

This paper presents the evidence gathered over a four-year period in one orchard that codling moth injury and population may be reduced by the use of light

traps. Data indicating that under the given experimental conditions the reduction in injury was apparently comparable to that achieved through the application of two lead arsenate cover sprays is presented in graphic form, together with a discussion of the conditions that obtained.

34. Past and Present Performance of Spray Schedules Used in 1936. (5 min.) G. EDWARD MARSHALL, Orleans, Ind.

Many combinations of fluorines, nicotines, pyrethrum and other arsenical substitutes for lead have been used for the control of codling moth. Combinations of lead arsenate–summer oil–soap if properly mixed and if applied according to the newly developed methods of control, will check the most severe infestations and permit satisfactory residue removal.

35. Effect of Different Spreaders on Nicotine in Thrips Control. (7 min.) C. O. EDDY and S. S. SHARPE, Baton Rouge, La.

Experiments with *Frankliniella fusca* Hinds and *Thrips tabaci* Lind. show that various spreaders markedly affect the toxicity of nicotine. They further indicate that nicotine, when combined with the proper spreader, may be used economically in the control of these two species of thrips.

36. Karaya Gum in Nicotine Sprays. (5 min.) C. O. EDDY and C. M. MEADOWS, Baton Rouge, La.

Experiments in the control of two species of aphids show that the nicotine in nicotine-spreader combinations may be reduced up to two-thirds by the use of karaya gum.

37. Notes on the Fumigation of Insect Eggs. (10 min.) R. T. COTTON, GEORGE B. WAGNER and H. D. YOUNG, Manhattan, Kans.

A study of the relative susceptibility to standard fumigants of the eggs of several common stored-cereal product insect pests.

38. The Fumigation of Baled Cotton with Hydrocyanic Acid. (10 min., lantern.) A. C. JOHNSON and LON A. HAWKINS, Beltsville, Md.

The fumigation of baled cotton under reduced pressures, partial vacuum, for the pink bollworm was the first large-scale application of this process, and was applied first to imported cotton and later to domestic cotton which might be infested with the pink bollworm. In the investigations carried on over a period of approximately eight years, the dosage of hydrocyanic acid to produce a complete kill of the insect under commercial conditions was determined. The effect of temperature, length of exposure, and methods of removing the residual hydrocyanic acid from the cotton bale, and the proper method of stacking and introduction of the fumigant to obtain best distribution were determined. The method of applying the treatment under commercial conditions was standardized.

39. A Study of Low Temperature as a Possible Means of Controlling the Tobacco Beetle in Stored Tobacco. (10 min.) M. C. SWINGLE, Beltsville, Md.

A series of tests were made on the various stages of the tobacco beetle, *Lasioderma serricorne*, to find the minimum exposure required for complete mortality at temperatures ranging from 10 to 40° F. A one-hour exposure at 10° was sufficient to kill all stages excepting the larval, which was not tested at this temperature. At 40° eggs were killed in 16 days, larvae in 20 days, and adults in 33 days. A complete kill of pupae was not obtained at 40°. Eggs, larvae and pupae exhibited an increased resistance in the range from 20 to 35°. Approximately the same exposure was required to kill at 33° as at 29°. Bales of cigar tobacco placed in a 10° room cooled from 64° F to 15° F in from 2½ to 5½ days depending on the size, shape and covering of the bale. Fifteen days were required for the center of a hogshead to cool through the same range.

40. *Lineodes integra* Zell., A Potential Pest of Greenhouse Tomatoes. (10 min., lantern.) C. C. COMPTON, Urbana, Ill.

Lineodes integra Zell., feeds on all parts of the tomato plant growing above the soil level, including the stem, foliage, buds and fruit. While occasionally found on outdoor-grown tomatoes and other Solanaceae it is not recorded as a pest of this crop. On greenhouse tomatoes it is capable of causing severe losses because of its habit of attacking the green fruit. Notes on life history and control are given.

41. Effect of High Concentration and Short Exposure in Nicotine Fumigation. (By title only.) J. F. ALSTERLUND and C. C. COMPTON, Urbana, Ill.

A series of greenhouse fumigations with combustible nicotine-impregnated tobacco powder is reported, with the black mum aphid, *Macrosiphum sanborni* Gillette, as principal test insect. Several methods of handling the burning powder are described. The most effective method was one employing a new type of pressure-fumigating can, from which the nicotine vapor discharges with considerable force. The can while burning is carried along the greenhouse walks and allowed to discharge directly onto the bench. In this way a temporary heavy concentration of nicotine is created immediately surrounding the plants. Results thus secured in the greenhouse are compared with effects of field fumigation of the pea aphid, *Macrosiphum pisi* (Kaltenbach), by the nicotine vaporizer in 1936.

1:30 p.m., Viking Room

42. Preliminary Report on the Relationship of Certain Insects to the Dissemination of Azalea Flower Spot Disease. (10 min., lantern.) FLOYD F. SMITH, Beltsville, Md.

Observations made near Charleston, S. C., during the flowering seasons of 1934 to 1936 indicated that the most common insects frequenting azalea flowers were thrips, *Frankliniella tritici* Fitch and *Heterothrips aesculi* Watson, *Emphoropsis floridans* (Smith), *Bombus* spp., *Xylocopa* spp. and *Apis mellifera* L. Viable spores of the causative fungus were observed on the tibiae and tarsi of *Bombus*, *Emphoropsis* and *Xylocopa* after capture on azalea flowers. In a series of 587 laboratory tests conducted during 1936, all of the flowers exposed to thrips remained healthy while a varying percentage of the flowers exposed to the bees became infected. Bees captured .5 mile from any known diseased azalea flowers induced infection. Marked *Bombus* spp. and *Emphoropsis* were found to travel for at least .8 mile.

43. Control of Onion Thrips on Greenhouse Cucumbers. (5 min.) C. A. WEIGEL and R. H. NELSON, Beltsville, Md.

Sprays composed of derris powder and of cubé powder, alone and in combination with pyrethrum extract, as well as aliphatic thiocyanate sprays, have been tested against the onion thrips, *Thrips tabaci* Lind., on greenhouse cucumbers. The cubé powder was less effective than the derris powder even though the rotenone content of the two sprays was the same. The addition of pyrethrum extract increased the efficiency of both. The aliphatic thiocyanates gave fair to good control depending upon the dilution used.

44. The Iris Thrips and Its Control by Hot-water Immersion with Notes on Insecticidal Treatments. (10 min., lantern.) FLOYD F. SMITH, Beltsville, Md., and L. G. UTTER, Brooklyn Botanic Garden, N. Y.

The iris thrips, *Bregmatothrips iridis* Watson, now known from nine states, is primarily a pest of iris by injurying the foliage and to some extent the flowers. General observations on the seasonal history and appearance of macropterous forms are given. In control tests infested plants have been freed of thrips by a 30-minute immersion in water at 110° F, and the best season for treatment of

most iris has been determined. In preliminary tests a spray containing derris powder proved to be the most effective of five materials tested.

45. White Coating on Foliage, a Repellent for Potato Leafhopper. (3 min.) E. I. McDaniel, East Lansing, Mich.

Based on two seasons' operations we find that any white coating on the foliage serves as an effective repellent against the potato leafhopper.

46. The Hollyhock Thrips, *Liothrips varicornis* Hood. (10 min., lantern.) S. F. Bailey, Davis, Calif.

The life history, habits, seasonal abundance and distribution of *Liothrips varicornis* Hood are given together with a brief description of the immature stages. The injury to hollyhocks is discussed and illustrated.

47. Notes on the Control of Some Pests of Ornamentals. (7 min.) W. E. Blauvelt, Ithaca, N. Y.

48. *Homaledra sabalella* Chambers, the Major Pest of Palms in Florida. (10 min.) John T. Creighton, Gainesville, Fla.

A brief treatise of the economic importance, food plants, life history and habits, temperature studies, distribution, natural and artificial control.

49. The Pea Aphis. (10 min., lantern.) C. Graham, College Park, Md.

Several years' use of nicotine plus a spreader has shown increased yields. Rotenone plus a sulfated alcohol spreader has given outstanding results this year, contrary to the results of the previous year when the rotenone was used without the spreader.

50. Control of the Larvae of the Diamond-back Moth, *Plutella maculipennis* Curtis. (10 min., lantern.) Harry G. Walker and Lauren D. Anderson, Norfolk, Va.

Applications of arsenical dusts and derris and cubé dusts containing approximately .75 per cent rotenone at the rate of 20 to 25 pounds per acre at week to 10-day intervals have given good control of the larvae of the diamond-back moth. These dusts did not seem to be very effective against the nearly full-grown larvae as most of them were able to complete their life cycle. However, very few of the newly hatched larvae were able to survive, and repeated dustings resulted in good control.

51. Life-history Notes on *Eriopyga incincta* Morr. in Kansas. (5 min.) H. H. Walkden, Manhattan, Kans.

Notes on the seasonal history and life cycle of this noctuid.

52. Further Observations on the Histology and Physiology of the Psyllid Yellows Disease of Irish Potatoes. (10 min., lantern.) J. R. Eyer, State College, N. M.

This paper includes a discussion of the feeding processes of the nymphs of *Paratrioza cockerelli* Sulc., and their effect on the vascular tissues and plastids of the potato plant. The resulting changes in the carbohydrate and nitrogen metabolism are also explained.

53. Progress in the Control of the Alfalfa Snout Beetle, *Brachyrhinus ligustici* L. in New York. (15 min., lantern.) C. E. Palm, C. G. Lincoln and C. P. Zorsch, Ithaca, N. Y.

A progress report on control measures used on all known infested farms in northern New York in 1936. Also a discussion of cultural practices being employed in control program. Further data on biology and wild host plants of adults and larvae.

54. Dust for the Control of the Strawberry Weevil, *Anthonomus signa-*

tus Say, in Virginia. (5 min., lantern.) LAUREN D. ANDERSON and HARRY G. WALKER, Norfolk, Va.

In this experiment each material was applied to five beds of Big Joe strawberries, 5 by 120 feet, replicated four times. Applications of 40 pounds of dust per acre were made on April 23 and 29. The materials and proportions used, yields of prime berries, and per cent of buds cut per treatment are as follows: sulfur–lead arsenate (5:1), 86 quarts, 30 per cent buds cut; hydrated lime–lead arsenate (5:1), 86 quarts, 28 per cent buds cut; sulfur–calcium arsenate (5:1), 70 quarts, 22 per cent buds cut; sulfur–finely ground derris root containing 5 per cent rotenone (17:3), 77 quarts, 26 per cent buds cut; untreated, 53 quarts, 50 per cent buds cut. A difference of 4.5 per cent in number of buds cut, and 12 per cent in quarts may be considered significant. Heavy frost and drouth decreased the yield uniformly in all plats. The percentage of buds cut in the treated plats appears higher than it should, as 17 per cent of the buds were cut in all plats before treatment. The sulfur–calcium arsenate mixture gave marked foliage injury.

55. Experiments for the Control of the Sugar Beet Leafhopper. (5 min.) L. W. CAMPBELL, San Francisco, Calif.

Recent experiments with pyrethrum sprays applied by an airplane and a ground vaporizing machine revealed that, with a proper type of base oil used in combination with pyrethrum extract, both the airplane type of vaporized spray and the ground vaporized spray have better than 96 per cent control of sugar beet leafhopper. The ground vaporizing machine applied 5 to 6 gallons of spray per acre and sprayed 60 acres per day. The airplane sprayed 100 acres per hour. The results obtained from both methods were comparable.

56. Tests with Bait and Light to Trap the Codling Moth. (10 min., lantern.) H. N. WORTHLEY, State College, Pa.

Tests in three seasons showed light to be far more attractive to adult codling moths of both sexes than a fermenting molasses bait. An inexpensive device containing both bait and light caught as many months as the electrocuting type of light trap.

57. Grenz Radiographs of Sulfur Dispersion on Foliage. (10 min., lantern.) G. F. MACLEOD, Ithaca, N. Y.

The use of soft X-ray photographs to show the dispersion of sulfur in wettable sulfur sprays on foliage will be shown with slides. No marked differences in dispersion are evident although sedimentation tests gave decided differences in wettability of the mixtures.

58. Concentration-mortality Curves in Comparisons of Relative Toxicities. (10 min., lantern.) H. MENUSAN, JR., Ithaca, N. Y.

By varying the time of exposure or the temperature at which bean weevil, *Bruchus obtectus* Say, eggs were exposed, it was possible to obtain time and temperature mortality curves. A statistical examination of the results indicates that the median lethal dose is the most variable point on the mortality curves for comparisons of relative toxicities. Variations between replicates in the median range were threefold than at either the lower (10 per cent) or higher (90 per cent) ranges of the toxicity curves.

59. Results of Experiments for the Control of the Hairy Chinch Bug, *Blissus hirtus* Mont. (10 min., lantern.) K. E. MAXWELL, Ithaca, N. Y.

Experiments for the control of chinch bugs in lawn grass compared the effectiveness of tobacco dust with rotenone dust and nicotine–soap sprays. The effect of timing of the treatments, the rate of application and the number of treatments per year are discussed.

SECTION OF PLANT QUARANTINE AND INSPECTION

9:30 a.m., Tower Room

M. S. YEOMANS, Chairman E. L. CHAMBERS, Secretary

Appointment of Committees on Resolutions and on Nominations.

Address by the Chairman, M. S. YEOMANS, Atlanta, Ga.

1. Origin and Development of the Canadian Plant Inspection Service. W. N. KEENAN, Ottawa, Can.

2. Federal Plant Quarantine Work in Puerto Rico. W. A. MCCUBBIN, Mayaguez, Puerto Rico.

3. Foreign Plant Quarantine Work in the Lower Rio Grande Valley. O. D. DEPUTY, Brownsville, Tex.

4. A Departure in Plant Certification Methods. TOM O'NEILL, Atlanta, Ga.

5. Status of Potato Wart Control in Pennsylvania. R. H. BELL, Harrisburg, Pa.

6. Some Quarantine Phases of the Potato Wart Disease. B. M. GADDIS, Washington, D. C.

7. Some Pathological Phases of the Potato Wart Disease. E. S. SCHULTZ, Beltsville, Md.

1:30 p.m., Tower Room

8. Important Features of Nursery Inspection. G. M. BENTLEY, Knoxville, Tenn.

9. Should Scale-Infested Conifers Grown in Forest Nurseries be Planted in Forested Areas? A. G. RUGGLES, St. Paul, Minn.

10. White Grub Devastations in Iowa Nurseries. FLOYD ANDRE, Ames, Iowa.

11. The Present Grasshopper Situation in Iowa. C. J. DRAKE and G. C. DECKER, Ames, Iowa.

12. Recent Disease Eradication Work in North Carolina. R. W. LEIBY, Raleigh, N. C.

13. Preliminary Report of the Relationship of Certain Insects to the Dissemination of Azalea Flower Spot Disease. F. F. SMITH, Beltsville, Md.

14. The Vetch Bruchid, *Bruchus brachialis* Fahraeus, J. S. PICKNEY, Carlisle, Pa.

15. The Alfalfa Snout Beetle, *Brachyrhinus ligustici*. P. N. ANNAND, Bureau of Entomology and Plant Quarantine.

16. Progress of Japanese Beetle Suppression in St. Louis. J. CARL DAWSON, Jefferson City, Mo.

17. Accomplishments of the Bureau of Entomology and Plant Quarantine under the Emergency Funds. LEE A. STRONG, Washington, D. C.

Report of the National Plant Board. J. F. ADAMS, Chairman, Newark, Del.
Reports of the Regional Boards.

The Eastern Plant Board. ERNEST N. CORY, Sec'y-Treas., College Park, Md.

The Central Plant Board. P. T. ULMAN, Sec'y, Indianapolis, Ind.

The Southern Plant Board. J. H. MONTGOMERY, Sec'y, Gainesville, Fla.

The Western Plant Board. A. C. FLEURY, Sec'y-Treas., Sacramento, Calif.

Report of Resolutions Committee.
Report of Nominating Committee.
Selection of Officers.
Adjournment.

Thursday, December 31

GENERAL SESSION

(Final Business Session)

9:30 a.m., Viking Room

Papers Carried Over.
Report of Committee on Resolutions.
Report of Committee on Membership.
Nomination of Journal Officers by Advisory Committee.
Report of Committee on Nominations.
Election of Officers.
Miscellaneous Business.
Fixing Time and Place of Next Annual Meeting.
Adjournment.

L. S. MCLAINE, *President*
Ottawa, Can.

ERNEST N. CORY, *Secretary*
College Park, Md.

CODLING MOTH CONFERENCE

The Association's Codling Moth Committee is arranging for a general conference on the codling moth problem, similar to those of recent years, to be held at Atlantic City immediately after the close of the general sessions of the Association. A more detailed announcement will be sent out by the Committee as soon as plans for the conference have been perfected.

B. A. Porter, Chairman, Codling Moth Committee